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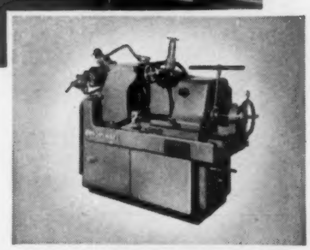

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The Institution of Production Engineers Journal
VOL. 34 NO. 1 JANUARY 1955

Education and Research for Production

by H. W. WRIGHT-BAKER, D.Sc., M.I.Mech.E.

Professor of Mechanical Engineering, College of Technology, Manchester.

THE problem implied in this title will obviously vary as widely as the meanings which may be attached to the words. When, between birth and death, does "education" stop? Where, between the design of space-ships and the disentangling of daily problems, does "research" lie, and what is meant by Production?

If the latter implies "maintenance, line production and design in the field of standard practice", it would seem that "research" should be replaced by "development", and that "education" might well stop at 21, and should include both a full measure of the study of accepted plans and procedures and an ability to note the trend of current changes and to take a proper part in evaluating, adopting and perhaps anticipating them. For this the Higher National Certificate holders, with long industrial training, or the Ordinary Degree men with less industrial experience but very substantially wider academic background, may suit admirably. Perhaps one might go so far as to associate the adjective "Ordinary" with the man rather than with the Degree, but not as a term of disparagement.

Geniuses, who are "born and not made", present quite other problems in education, perhaps that of devising ways of permitting them to crash through the rules and regulations which help to guide the courses of lesser people, while maintaining some measure of academic propriety. No one would question the use of "research" in relation to such men, as it permeates the whole course of their thinking, and is basic to their work. This is obviously not the place to discuss the pseudo-genius.

Importance of the 'Middlemen'

Between these two groups lies a third—the average or good 'Honours' men, who form the backbone of all University schools and provide the bulk of their representatives in industry.

It is not a matter for surprise that some of those in high places in academic spheres, who have been selected individually for their seats of learning on the grounds of their own peculiarities, should find group one uninteresting and the middlemen a little dull at times; or that those who have "come up the hard way" should be scared stiff by genius, which at least in the lower forms is often combined with a certain "queerness", and look with uneasiness at any signs of infection among the middle grade.

It is this centre group with which I am concerned. For genius the best we can do is to keep the way open for the passage of those who possess this virtue, and encourage those genuine cases in which it may still lie dormant or undeveloped. The Higher National Certificate men perform the tasks of today with the efficiency which brings us our bread and butter, our shelter and our side-shows. Some may go much further, and seeds of genius are sometimes found in them. But the motions which have so effectively operated the slides of our locomotives will not operate the slides of our precision profile miller, the hand-wheels of tomorrow will spin too fast for the hands which now operate them, machines are beginning to take their instructions directly in their own language and not through the medium of an interpreter-operator. In these and many other fields the man who has received fair doses of only Strength of Materials, Theory of Machines and one other subject cannot lead, though he may still "operate and maintain". We must sympathise with those who

see younger men outstripping them after a seemingly easier start, but it is inevitable, and they cannot have it both ways anyhow. It was more pique than wisdom which, a good many years ago, prompted a member of the good old school of "practical engineers" to reproach my predecessor, Dempster Smith, for his quite unrealistically academic outlook, and then chastise him for advocating the use of a cutting tool which worked only twice as fast as anything known before, when what was wanted was one which worked ten times quicker.

Let it be admitted also that in many ways our educational system has tended to swing too far towards an attempt to cultivate exceptional abilities—Higher National Certificates for those whom Nature intended to be craftsmen, and Degrees for those for whom less baffling courses could well have been adapted with profit. The list of failures on the ladder from S.1 to A.2 surely carries a glint of moonshine, but to fail to train a man to the proper limit of his abilities would be equally foolish. Industry requires young engineers who have the ability to think and to assess, and who, after a relatively short period in industry itself, will be able to play a part in the making of wise decisions and in directing and controlling the complex units of men, machinery and capital necessary for the achievement of favourable results.

The training of these men allows no insertion of "easy options" in a standard course—the equivalent of the substitution of lectures on "Medical Quackery" for the more serious matters in the final years for the degree of M.B. There must be the full strength and solidity associated with normal practices relating to the training of mechanical engineers, and from which there can be no divorce, but there is both a need and a justification for bias when an adequately universal scheme is no longer even a dream. The course may be easier, perhaps, to the non-mathematical, but harder to those who expect all questions to give unique and precise answers in unlimited time, and who may lack the ability to work swiftly and logically through twenty seemingly conflicting arguments all tangled together, in order to select an answer which, though it is not unique, will yet result in the achievement of the desired goal within reasonable limits and have an evaluated superiority over the rest.

Consideration of Age Groups

No scheme of education can be planned without reference to the age-group involved. In the present case it is particularly important to study basic principles and the rules of thought while minds are receptive and elastic and before ideas of authoritarian discipline become distasteful. Only after that can one learn to steer safely an even slightly unconventional route through the hazards of pocket-book data, or tread wisely among the persuasions and politics of advertisement and the not altogether disinterested views of the writers of papers. Nor can the intricacies of personal relationships be passed on effectively to those who are still only beginning to lay the foundations of an understanding of their own personalities, though much useful help can be given them along unobtrusive parental lines—a time-consuming job for those who teach. Personal relationships are not mathematical integrations, and, though some of the elements were laid within us long before cradle-days, a real understanding is surely a post-graduate study for most folk, and only Dictators wielding the threat of death itself can say with certainty that two and two make four.

The first two years of a Degree course cannot depart far from traditional lines. The basic principles and the well-tried tools of logical thought and expression must be understood, and there is little which can be left out of the normal syllabus—though there may be need for reconsideration. Mathematics should be studied both as a tool of great power, as a pointer to the fact that things which can be treated in the same way must have a unity in spite of the diversity of the phenomena with which they are commonly associated, and as a subject which if not mastered under tuition will hardly ever be mastered at all.

Physics and Chemistry which explain the nature of the parts, and Mechanics which explains their relationship; a knowledge of metals and other materials, and of the forces which will break or distort them; the theories of machines and relative motions; the laws underlying the flow of the liquids and gases which play such a large part in the processes later to be harnessed in servo-mechanisms and even ventilating systems; the heat which we use so much less than we think and which will figure correspondingly heavily in the bills, and electricity without which many things would be impossible. On two counts only can much still be done—the reorientation of laboratory work towards the acquisition of precise facts rather than the more vague and often unconvincing illustration of "principles", and the deflection of the Drawing Office away from the production of drawings and towards the use of drawings as a

means of conveying precise thoughts in a logical manner, and in relation to problems which are not as simple as they sometimes seem.

It is in the third year of the Honours course that a real change can be made to the traditional syllabus. Though the theories of Materials, Machines and Structures can follow a fairly normal course of development—provided always that the bias is in the direction required by Mechanical Engineers—Mathematics will lead to Statistics, Hydraulics will unite with Electronics in the common service of Servo-mechanisms—Heat will be considered for its direct use rather than after conversion into power—and an understanding of electrical measurement and control will take the place of further theoretical development.

Engineering design will be directed towards the goal of production, with all that that entails; the basic problems of metal cutting and processing will precede the study of the machines on which they are used and concerning which the emphasis will be on principles rather than mere description. Precision measurement may have to be applied to the work-piece, and precision control to the tool, and the principles of standardisation can be directed to components, raw material and finished products, to the machines and the treatments employed.

The background to plant layout, production control, etc., will take a small but compact place, factory law will be introduced, and consideration given to such sections of Management Principles, Personnel Control, etc., as may be appropriate to the age-group. During much of this work the reins may well be slackened so that discussion—and sometimes keen argument—can take place concerning relative merits and rival theories, and over a pile of drawings labelled "Rolls Royce" or "Production Unlimited", of gas turbines, textile machinery or teaspoons. The student will prepare his own schemes and learn to defend them in discussion, in the end before an external examiner of recognised authority as a production engineer.

The Place of Research

But where does Research come in? The answer is at the bottom of the pile. So much is out of date before the next textbook comes out, and the discrepancies between old theory and new practice can at times be so glaring that no teacher can continue to inspire unless he himself is pushing forward into the unknown. Nor can he do this for long alone. Research into production problems is no "one-man band," and in a live department one specialist will seek the help of others in different lines —metallurgists, physicists, metrologists and many sorts of engineers will group together over details of specific problems as occasion may require. Let there be no mistake about it—industry will be there too, sometimes perhaps a little bewildered, but keen and helpful. In fact, without their interest there would be no drawings to discuss, no more material than will serve to stimulate cupidity, no tools or instruments which modern industry would tolerate, no battle of wits on territory which industry alone controls in the end.

In his third year, then, the student will begin to feel his feet to be planted upon the field of his choice, and his previous studies will at last begin to appear as parts of a consistent whole. The otherwise "bald and unconvincing narrative" will acquire a real significance, and enthusiasm will warm as he sees the ideas for tomorrow growing in the laboratories in which he himself is working.

If, as will sometimes be the case, he can stay on for a further year or more of "research", he will learn many new things—the systematic development of new ideas and their verification, the interlocking of the branches of knowledge, the interplay and responsibilities of members of a team, and the presentation of conclusions to a competent and critical world. It should perhaps be stressed that there is a marked difference between "research" and "student projects"—as different as is the "View Hallo" from a pot-shot at a sitting hare, which one has a shrewd suspicion has already been done to death and stuffed.

There are naturally many fields of investigation in Production Engineering which by their nature are unsuitable for internal University "research"; there are others in this and all branches of engineering in which the experiments, to be realistic, must spread into the shops and laboratories of industry, but this presents no difficulty when each side respects the other. It seems essential however, that the spirit of research and enquiry should penetrate deeply, that the problems should be pressing, and that those who are involved should be able to call in the help of others when specialised knowledge is required. Some of the Universities and Colleges with their well-established specialised schools are potentially able to provide the nuclei of teams which, in some areas at any rate, industry has shown not only willingness but

enthusiasm to join. Let those academic purists who would fear to lose their beloved —and very proper—freedom were they to play with industry, contemplate the fact that the costly tools so essential to modern research can seldom be requisitioned on their departmental budgets. There is a most encouragingly true variant to the old gag: "Blessed is he who asketh nothing, for he will surely get it".

Such terms will not tackle the day-old worries of industry, nor can they be expected to produce answers to complex questions at short notice, but they have in them the possibilities of tackling problems which lie outside the range of all but the very largest industrial research laboratories or institutions.

Value of Refresher Courses

In the study of "live" problems information, ideas and perplexities will be drawn together from many sources, and very often these will lead to "refresher" courses planned to bring old hands up-to-date and show them how modern knowledge and practices are developing in their own fields. We have no "refresher" courses for craftsmen as Sweden has, but some regions have done excellent and greatly appreciated work at many levels up to that of Managing Director and Production Manager, and why not? It is only general education which stops at 21. Courses dealing with the more intricate branches of Management will only start at that age, and those dealing with such matters as time and motion study will be more soundly effective when both the processes and the people involved are better known.

A well-founded and vigorous course will spread its influence in many directions. If Higher National Certificate courses in Production subjects are operated in the same laboratories and under the guidance of members of the team the fire will spread to them; syllabuses may be re-moulded and Post Higher National Certificate courses be devised to meet particular local or national needs. On the latter scale, short refresher courses dealing with specific sections of the work and offered to teachers of technical subjects can result in some astonishingly effective huddles of enthusiasts.

Need for Additional Grants

Where the scientific and technical ability, the appropriate equipment and the collaboration exist, there still remain two difficulties. There is a great shortage of grants to enable students who may have acquired a keen interest in production problems to join a research team for a while. This is particularly to be regretted when it is remembered that such researches not only contribute to knowledge but also provide training in the orderly assessment and solution of complex problems and in systematic team-work, and contribute to the development of an attitude of mind which expects and anticipates technological changes and is prepared to contribute to their adoption.

While many foreign students receive grants from their own Governments to enable them to obtain experience on these lines, it is a pity that our own men find serious financial and other difficulties in their way.

Every research involves the construction of special instruments or the making of intricate adaptations, and a great deal of time can be saved if funds are available to enable a skilled instrument maker or technician to be employed on the preparations for a specific research for an appropriate time. Research students have much to learn concerning design and calibration, and some experience of instrument making may have its place, but far too much of their time is often wasted in the actual making of the bits and pieces—often so much that the job itself is finally left incomplete.

In education, as in production engineering, there can be no single and perfect solution. There must be many other factors to consider and weigh in developing or modifying the ideas given above; perhaps they may be suitable for one area but not for another. They have the merit, however, of having developed slowly, many people and many experiments have contributed to them, and fruit has already been gathered.

THE DEVELOPMENT AND MANUFACTURE OF JIG BORING MACHINERY

by W. H. JAYE, B.Sc.Eng.(Lond.).

Presented to the Birmingham Section of the Institution, 17th March, 1954.

In 1930 Mr. Jaye obtained an External London Engineering Degree in Mechanical Engineering after studying at University College, Southampton, where he also obtained a 1st Class Engineering Diploma.

After serving an apprenticeship with Alfred Herbert, Limited, at Coventry, Mr. Jaye was transferred to their London Machine Tool Showroom as Demonstrator, in 1933. For the next four or five years he carried out the duties of Service Engineer for the London Area and specialised in the Coventry dieheads and dies.

In 1938, Mr. Jaye joined Messrs. H. E. Weatherley & Company as Installation and Service Engineer for the products of Societe Genevoise d'Instruments de Physique, for whom his company were Southern agents.

During the War years he was occupied with the development of a project for rebuilding enemy blitzed or badly worn jig boring machinery manufactured by the Societe Genevoise.

In 1945, his services as Works Manager were transferred to Sogenique (Service) Limited, who became the Service Organisation for all G.S.I.P. products. A specialised factory was developed at Newport Pagnell, Bucks., to provide every aspect of service, including complete rebuilding of the earlier models, and Mr. Jaye has continued in the capacity of Works Manager to the present time.

Mr. Jaye

It would seem logical to commence this Paper with a brief description of the different types of jig boring machine which are available to industry at the present time.

This list of types of machine will include only those machines which have been specifically designed for use as precision boring machines. In other words, the descriptions will not be intended to cover vertical milling machines or horizontal milling machines which have simply been adapted for jig boring purposes by the application of some measuring system to the movable elements.

It can be said that machines which have been designed as jig boring machines fall into three main groups:—

1. the group of single-column machines with vertically disposed boring spindles;

2. the bridge-type machines with vertical spindles or a combination of vertical and horizontal spindles;

3. the single-column machine with horizontally disposed spindles only.

The means of obtaining accurate displacement of the machine elements on jig boring equipment can be classified into the following clearly defined groups.

First, a system of end measuring rods in conjunction with a micrometer and fiducial indicating device. In this general group can be considered those machines which utilise a nest of accurately lapped cylindrical rollers, with a micrometric device for sub-division and used with a fiducial indicating device.

Another system in general use utilises precision micrometer lead screws equipped with a pitch error correcting device which enables a higher degree of accuracy to be obtained than would be the case if the lead screws were used simply as produced. In this group can be considered certain small economical machines which rely upon uncorrected lead screws.

Extensively used is a measuring system which employs built-in high precision standard scales viewed through a high-power micrometer microscope, or projection screens.

Another system which uses a spiral line drawn around the surface of a long cylinder and viewed through a suitable microscope can be included in this group of optically set machines.

There has also recently been developed a system which employs a standard composed of a notched bar of magnetic material, which has been magnetised in

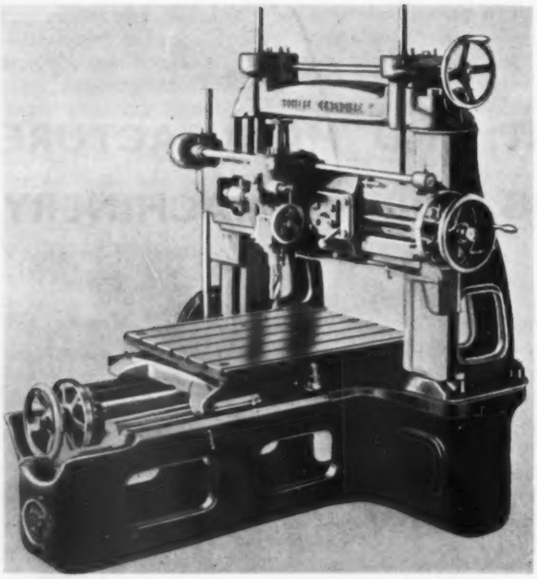


Fig. 1. Prototype bridge type jig boring machine made in 1920.

such a manner that its magnetic poles are spaced with considerable accuracy along its length.

It is interesting to note that in every one of the above mentioned systems the micrometer screw is ultimately used to sub-divide the measuring units.

It is probably true to say that every jig boring machine that has been produced to date takes one of the three forms already mentioned and utilises one or other of the measuring means just described.

The time and space available for this Paper is quite inadequate to describe in any detail all of the available machines, even supposing the Author's knowledge was sufficient to cope with this formidable task. Therefore it has been decided to concentrate on one type of machine so that a modicum of technical detail can be presented.

History and Development

There is little doubt that the type of jig boring machine which has the longest continuous history of development is that which emanated from Switzerland at the end of the First World War, and which takes a form somewhat geometrically similar to a bridge-type planing machine.

It is the history, development and manufacture of this particular type of jig boring machine that will be the subject of the rest of this Paper.

During the closing years of the 1914-18 War, a small machine known as a "pointing machine" was in use in the watchmaking industry to mark out accurately in rectangular or polar co-ordinates the master jigs used to drill the top and bottom plates of watches. The machine utilised two micrometer screws at right angles to each other and equipped with pitch correcting devices. These screws were used to position in rectangular co-ordinates a head containing an automatic punching device over a small work-table.

The capacity of these small bench machines was of the order of 3″ x 4″ or 4″ x 5″ and they were used only to centre-punch the work-piece. There was also a locating microscope which could be interchanged with the spotting tool for the examination or setting of the work-piece. The application of a small spindle driven by a flexible cable, to enable holes to be drilled after the centre punching operation and before the work-piece was removed, was the next quite natural development.

This development was in fact to prove to be the birth of the first jig boring machine. Almost immediately the designers began to work on a machine of much greater capacity, which would have the ability to machine the types of jigs and fixtures made in a large number of tool-rooms.

The prototype of a machine of a capacity of 24″x 18″ was made and, in spite of its extremely elementary construction compared with modern machines, it proved to be extremely fast in operation and able to produce work of an accuracy exceeding the very best work of the skilled toolmaker using buttons and slip gauges or other current methods.

The first machine offered for sale was, in fact, an improved version of this prototype and was purchased by a prominent concern in this country in 1922. It is still in operation after all these years.

In 1923 a larger machine of similar construction was made having a capacity of 32″ x 24″ and the

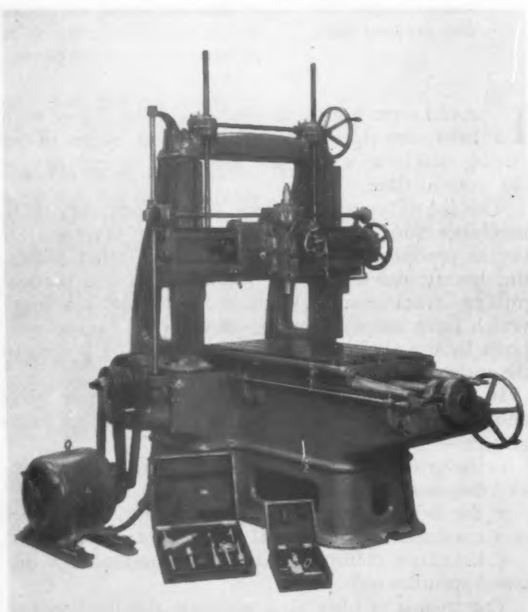


Fig. 2. 32″ x 24″ machine introduced about 1923.

machines were now equipped with two spindles mounted side by side and separated by an exact multiple of millimetres or inches, so that each spindle could be brought over any chosen position by the simple movement of the spindle carriage a round number of millimetres or inches. The purpose of the second spindle, which was arranged to have a much higher speed range than the main spindle, was to enable accurate centre drilling to be effected and to permit small diameter holes to be drilled and finished at economical speeds.

A very large machine of 52″ x 40″ capacity was perfected in 1925 and for the next few years rapid developments took place in the rigidity of the design. Boring spindles became stronger, more spindle speeds and feeds were provided and certain of the larger machines were equipped with motorised rapid traverses to the elevation of the crossbeam, the spindle carriage and the machine work-table.

For some time the users and designers of this type of equipment had realised that a machine with three co-ordinates would prove extremely valuable for large box jig work, where the facility to bore holes in all faces of box castings at one setting would not only establish great savings of time, but would also considerably improve the possible accuracy of the result. During 1933 a machine of this type was introduced, the main features being a capacity of 52″ x 40″ x 28″; and three spindles, namely, a main and high speed vertical spindle and a large horizontal spindle equipped with an outboard bearing which could be optically aligned with it, thus allowing the use of long boring bars traversing the entire width of the work-table. The machine weighed about eight tons, and some interesting and difficult problems of metrology and mechanics had to be solved during its construction.

Right up to this time, i.e. 1933, it should be remembered that the means of setting the work-table and spindle head carriages was by precision lead screws and micrometer drums and verniers, the lead screws being equipped with pitch correcting devices. The machines were therefore designed as precision boring machines only and were intended to be utilised with clamped table and spindle carriage during the actual drilling or boring operation.

Milling on Screw Machines

So many times had the users enquired about the possibility of milling on these screw machines, that for some years a great deal of research had been carried out concerning the possibility of producing a machine which would be equally useful for boring holes or milling surfaces or slots with a precision comparable with the jig boring machine. The three main problems to be overcome were:—

1. to divorce the measuring system entirely from the stresses set up by traversing the machine elements past a rotating milling cutter;

2. to provide a spindle of suitable accuracy and rigidity which would be equally suitable to drill large diameter holes in hard material, to precision bore these holes in predetermined positions, to resist the entirely different forces set up when milling surfaces or sides of slots and, lastly, to accommodate precision measuring tools such as the centering dial indicator or locating microscope which was normally part of the accessory equipment of the jig boring machine;

3. to furnish the machine with suitable milling feeds to enable continuous feeding of the work-piece past the cutting tool at suitable rates of speed.

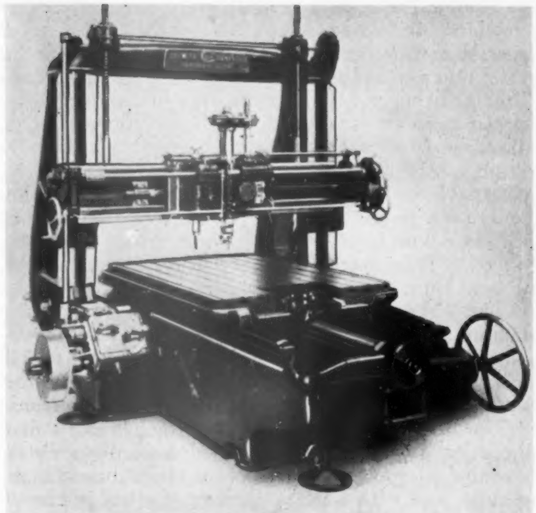


Fig. 3. Large jig boring machine 52″ x 40″ showing auxiliary high speed spindle.

How these problems were solved will be described later in this Paper.

However, from the historical point of view it may be of interest to know that after a most intensive effort a combined precision boring and milling machine was produced and shown at The International Machine Tool Exhibition at Olympia in London in 1934. The machine combined a high precision optical measuring system with a hydraulic traversing mechanism, and was the forerunner of the considerable range of optically set machines which is available at the present time.

The introduction of this machine did not sound the death-knell of the screw machines, some sizes of which are still being made as they are convenient, precise and economical.

The optical machine mentioned above was of such advanced design that it survived without major change for eighteen years and over 1,000 of them were manufactured.

From 1934 up to the commencement of World War II developments were continuously taking place in technique, and the screw-operated machines were redesigned to provide greater capacity, higher spindle speeds and increased ease of operation.

In 1939, after considerable experimental work, a prototype of a very large optical machine was constructed and exhibited at The National Fair at Zürich. Afterwards this machine was purchased by a prominent aircraft company in this country, where it worked all through the War years receiving, in fact, honourable scars from the efforts of Hitler's Luftwaffe.

There were certain revolutionary features on this machine, including a work-table traversing on a special anti-friction system of precision rollers and a hydraulically assisted cross-beam elevating mechanism. During the War years, in spite of the many preoccupations occasioned, much experimental work was completed with the result that in 1947 a really large machine incorporating optical, hydraulic and electrical features of great ingenuity became available and, a few months later, an even heavier machine of the same type, but having three co-ordinates, was produced. This machine, which is available at the present time, weighs over fourteen tons.

The above mentioned machines are now being manufactured with their micrometer microscopes replaced with a very effective projection system which shows the Standard Scale divisions, together with the setting graticule projected on translucent glass screens.

The original optical machine, which had its first inception in 1934, was superseded in 1952 by a machine of somewhat greater capacity beneath its spindle, and with a great number of other improvements designed to increase the accuracy obtained and the speed and facility of operation.

Precision Setting Guarantees

It is interesting to review the guarantees of precision of settings which the manufacturers found it possible to offer during the period which has just been covered, i.e. from 1922 to 1954.

From 1922 up to 1934, this guarantee ranged from .0002″ to .0004″ according to the capacity of the machine, the 24″ x 18″ machine being .0002″, the 32″ x 18″ being .0003″ and the 52″ x 40″ machine being .0004″.

In 1934, with the introduction of the optically set machine, it was found possible to reduce the error to .0002″ on a machine of 37″ x 28″.

When the large two and three co-ordinate machines were made in the years immediately following the end of the Second World War, those machines with a capacity of 57″ x 40″ were guaranteed to .0002″ and the latest optically set machine of 37″ x 28″ capacity is claimed to have a setting accuracy of .00015″.

Certain much smaller machines which are not of the bridge-type construction can be guaranteed to 2μ or .00008″, but they cannot be described in this Paper due to limitations of time and space. In any case, they are not of the bridge type construction.

The foregoing brief history is intended to serve as a framework for the descriptions which follow concerning some of the main technical difficulties which had to be overcome at each stage of development.

If we consider the period immediately following World War I and up to 1921, we find ourselves reviewing the period when the designers were trying to determine the best form to adopt for a two co-ordinate boring machine of considerable capacity (24″ x 18″) having up to that time only constructed the small bench-type locating machines, the design of which followed instrument practice rather than machine tool construction.

There is no doubt that the conclusions reached after careful analysis of all the limiting factors, and which resulted in the adoption of the bridge-type of machine, have stood up well to the test of time.

Importance of Stability

It may be of interest to record a few of the reasons for the decision to build the prototype in the form of a planing machine. The absolute necessity for extreme stability in order that any precision built into the machine by the makers would remain when the machine was transported to the users' works, was recognised as a matter of first importance. It was consequently decreed that each machine would be supported on three points only, so that any change in the user's foundation would not cause a deformation of the machine. The position of these three points had to be chosen with strict regard to a proper sharing of the load and with particular reference to the maximum deflection of the unsupported sections of the main bed casting.

A decision was made to provide complete support beneath each moving member of the machine, to obviate the inevitable sags that would occur due to any overhanging at extreme ends of travel.

Experience had already indicated that the ultimate accuracy of a machine of the type envisaged would depend on two main factors, namely:—

1. the precision of the two co-ordinate system whatever form it was to take, and

2. the accuracy with which the boring spindle could be maintained in any set position over the work-piece, even after long periods of high speed running of the spindle.

It was known that if the spindle were mounted at a considerable distance from its main supporting column, its position would vary by significant amounts, with quite small changes in temperature of the casting which connects the spindle quill to the main frame of the machine. Ambient temperature changes and the inevitable temperature rise which is occasioned frictionally after a period of high speed running of the spindle could, therefore, be expected seriously to mitigate against a constant spindle position in the case of a large single column machine with a "throat" division sufficient to accept a work-piece of, say, 24″ x 18″.

Effects of Temperature Change

It is interesting to consider the behaviour of the bridge-type machine under conditions of small temperature change. The distance between the spindle axis of this type of machine and the line of the front supporting faces of the two columns is only a matter of some five inches, as compared with a minimum of 18″—20″ in the single column construction. This fact alone must reduce the spindle axis movement due to similar temperature changes to a quarter of that found on the single-column machine. Furthermore, any differential temperature between one side of a single-column machine and the other will cause relatively large sideways deformation, the amount increasing according to the height of the spindle head above the point where the column joins the main base of the machine.

With the double-column construction the spindle head is always somewhere between the columns, each of which has approximately equal stiffness to lateral forces. The sideways movement of the spindle axis, therefore, is again lower by at least half when the bridge-type machine is subjected to the same relative differential temperature. A feature of the bridge-type machine is the manner in which the crossbeam is elevated by a pair of matched screws, so that the maximum amount of out-of-parallelism of the spindle carriage motion to the work-table surface can be kept to an absolute minimum.

The distance between the two elevating screws is never less than five to six times the maximum depth to which the machine will bore and, consequently, even supposing an error of matching of pitch of these two precision screws of .0005″, the effect on the verticality of the deepest hole would be less than .0001″ in the full quill travel.

There can be no doubt that the very greatest importance must be attached to the degree of straightness of the motion of the slides of a machine that is to produce accurate work at all heights, up to the maximum that will be accepted beneath the spindle when the latter is in its highest position. A simple computation will show that if an angular tilt of 5 seconds of arc should take place when a work-piece of 24″ height is traversed, the distance between holes bored in the top of the piece will be long or short by .0006″ according to the direction of tilt.

When this factor is considered in relation to the two-column machine, it will be noted that due to the complete independence of one co-ordinate system from the other, any small residual tilt of one slide does not have an effect on the displacement accuracy of the other slide at right angles to it, as is unfortunately the case with superimposed slides.

The adoption of the classic vee and flat ways to the main co-ordinate slide ways was another act of the pioneer designers which has ensured that, regardless of wear, the slide can never rock and is always firmly located.

Abbé's Principle

Perhaps the most important metrological consideration to which the designer for many reasons cannot adhere is that which is commonly known as Abbé's principle. Dr. Abbé, the distinguished physicist, formulated a condition which would limit the ill effect on precision measurement, brought about by errors of straightness of the guide ways of a measuring machine. The condition of minimum error was, Dr. Abbé demonstrated, when the measuring system was in line with the work-piece being measured.

Now, to adhere to this principle would result in a completely unpractical and ungainly machine, as the measuring elements would have to be in line with the work-piece, resulting in a machine of very great length and breadth. Furthermore, the measuring system would have to be capable of being elevated when machining tall work-pieces in order to maintain this desirable alignment.

There are two factors present in the bridge-type of machine which together permit the departure from

Fig. 4. Pitch correcting device of small jig boring machine of 18″ x 12″ capacity.

Abbé's principle to be made with the absolute minimum loss of precision, and these factors are:—

1. the basic rigidity of the design, which permits the ways to be finished to an extremely high order of straightness and which can be tested with optical instruments;

2. the provision of pitch correcting devices to each co-ordinate lead screw, which enables the machine to be standardised at the working plane as a last operation.

It is most important to understand that, in spite of the correcting device, the errors of straightness of the motion of the slides must still be left with a very few seconds of arc in the entire travel of the moving elements of the machine. If not, the standardisation effected by the employment of the correcting devices will only apply to the plane at which the machine was calibrated.

A high work-piece or a part which requires full extension of the spindle quill would result in errors of a magnitude right outside the guarantee mentioned earlier.

Some passing reference should be made at this point to the pitch-correcting device which has been referred to so frequently in this Paper.

In spite of the extremely precise and specially designed screw cutting appliances which had been developed to manufacture the lead screws of the jig boring machines, the overall accuracy was less than could be desired and a device was used which had the effect of applying rotation to the vernier to which the micrometer drum was set, in a direction and to an amount which would neutralise the pitch error at that position. This rotation was obtained *via* a lever with one end in contact with a metal template which was, in fact, a magnified version of the pitch error graph.

The manner in which the "calibration" and "standardisation" was carried out was as follows:—

A Standard Scale of very high precision and with known errors was mounted on the work-table of the borer with its axis in line with the table motion to be calibrated. The micrometric divisions of the scale were viewed through a high power microscope equipped with a micrometer eyepiece. The microscope was capable of being set to the hundredth thousand part of an inch. The table was traversed

and set successively at certain prearranged intervals, for example 1 cm. or .5″, according to which system of measuring units was in use, and the error from the true position was ascertained from the standard scale and microscope. With a knowledge of the ratio of the mechanical lever mechanism, it was a straightforward matter to produce a chart indicating the shape of the correction template required to reduce these errors to zero, or rather to the smallest practicable amount.

Straightness of Table Guideways

To revert to the question of the straightness of the table guideways, a somewhat special technique was developed to enable the straightness to be measured to very fine limits, utilising the autocollimator in conjunction with an optically worked mirror mounted on a special sliding carriage. It was possible, by this method, to provide guideways with a very small convexity to compensate for the inevitable small deflection of the bed when the heavy work-table was traversed along it.

Even the method of handscraping the guideway surfaces was found to have a considerable effect on the precision and speed with which settings could be made. The difference in the force required to move the table from rest and that required to maintain its movement, had to be reduced to a minimum to prevent loss of positional accuracy due to torsion in the lead screw, with its subsequent possible relaxation which inevitably was accompanied by a movement from the desired setting.

A form of handscraping was developed and perfected in which the operator drew the scraper towards himself, producing extremely shallow depressions of a more suitable profile than that given by the more conventional push scraper.

The combination of a special guideway handscraping and measuring technique, together with the correcting device, ensures that residual errors of straightness of guideways and of pitch of lead screws are removed by making the displacement correct at the working plane of the machine.

Furthermore, it is possible to recalibrate a machine of this type after a certain amount of wear has taken place, by a repetition of this process.

It may be of interest to know that the corrected lead screw device was developed by M. Marc Thury, an eminent Swiss engineer, in about 1862, when he was building the first linear dividing machine for the production of high precision Standard Scales.

Further Design Problems

Another problem that the designers of the early jig boring machines had to overcome, was concerned with the production of a boring spindle which would rotate with great accuracy about the axis and be strong enough to utilise quite large drills for roughing out the holes in the work-piece prior to the finish boring operations. It was also found possible to finish size holes in certain materials simply by feeding through the previously drilled holes a special sizing end mill cutting only on the ends of its teeth. This very speedy operation was found only to be possible if the tool-holding taper bore in the nose of the spindle rotated with about .00004″ or 1μ.

The type of spindles used on the very early machines had an upper cylindrical journal and a lower taper journal with a conicality of approximately one in ten. The thrust was taken by specially selected ball thrust races, selected to have the absolute minimum of axial movement when rotated. A setting washer was interposed between the lower collar of the spindle and the thrust race, and its thickness was so adjusted that there was a predetermined oil film thickness between the lower taper journal of the spindle and the bearing in the quill. This oil film was usually about .00012″ in thickness and the arrangement resulted in a very satisfactory boring spindle.

There was, however, a limit to the speed at which such a spindle could be rotated without warming up with the attendant difficulties; in the earlier machines the highest speed of this type of spindle was kept down to approximately 400 r.p.m. This speed, which was quite suitable for drilling and boring or end milling holes of 1″ diameter and over, was too slow for centre drilling or the drilling and boring of small diameter holes. It was for this reason that the designers conceived the idea of mounting a secondary high speed spindle on the same carriage as the main spindle and at a round number of inches from it, so that either spindle could be brought to the desired position quickly and without calculation. This combination of small high speed spindle and main spindle persisted until the early 1930's, when anti-friction bearings of sufficient precision were developed.

The Author hopes that the foregoing somewhat brief descriptions of the main problems facing the pioneer designers, and the measures adopted to overcome them, will serve to show how a clear analytical approach to the problem resulted in a simple yet elegant solution. Judged by present-day standards, the machines they produced were elementary indeed, but never once did the designers have to back-track and depart from the basic shape they had adopted.

Improving the Design

So much for the reasons behind the use of the planer type of jig boring machine construction; and now to the improvements which took place year by year.

The first developments, following the production of the early 24″ x 18″ models, were concerned with the production of larger machines and this involved the making of longer precision screw cutting machinery to finish the lead screws and elevating screws of these bigger models. It must not be thought, because a pitch correcting mechanism was employed on the jig boring machines, that the accuracy of the lead screws was of secondary importance. In fact, experience has shown that for a number of reasons the quality and accuracy of pitch of these lead screws is of the utmost consequence. Throughout the whole of the design and manufacture of precision machinery of this nature a number of main requirements must always be kept in mind, and some of the more important of these are as follows:—

1. the ability to repeat the positional settings with a precision of about one-fifth of the claimed accuracy of the machine;

2. complete uniformity of and minimum friction between the sliding members at all positions, in order that no undue residual compressive or torsional strain remains in the lead screws after a setting has been completed;

3. high quality of surface finish on all sliding surfaces to ensure long life and to enable extremely thin oil films to be maintained;

4. all moving mechanisms to be designed to run for long periods with the absolute minimum of temperature rise;

5. the metals used in the construction to be chosen with strict regard to their coefficient of linear expansion;

6. stabilisation of all the main castings and important components.

It will be observed that the first three factors mentioned have a direct bearing when considering .the quality of the lead screws of the machine. Without close uniformity of pitch the long lead screw nut cannot make intimate contact with the flanks of the screw along its entire length. Also, unless the surface finish on the flank of the screw is of a high quality the rate of wear of the nut and screw will be rapid and the "feel" of the machine will be heavy. It is possible to reduce the bearing load between the machine and the screw to as little as one or two pounds per square inch when the pitch and finish of a good screw and nut is really excellent.

The method employed to produce the lead screw of the jig boring machines has remained much the same for many years, although the machinery employed has been constantly improved. The screws are made of a stable steel which has been heat treated to produce a tough uniform blank. This blank is then screw cut on a specially-made screw cutting lathe which is equipped with a pitch correcting device. The lead screw of this special lathe is mounted immediately below the lead screw being cut, so that any parallax errors due to out-of-straightness of the machine bed ways are at a minimum. The screw is cut at low speeds and the depth of cut during the roughing out process is left low in order that no strain shall be left in the screw.

An elaborate steady surrounds the screw at the cutting point and travels with the tool. The screw has to be straightened and the final finishing cuts are extremely light to reduce the torque to which the screw is subjected, as this would seriously affect the pitch. The screw cutting operation has to be carried out under strict temperature control.

The finish and continuity of pitch is further improved by a mutual interaction with long adjustable nuts in a lapping operation. The length of accurate life of well-made screws, if kept clean and properly lubricated, is quite astonishing. Recalibration of table displacement of old machines has shown that after the equivalent of over fifteen years of normal wear the maximum error need not exceed 6 to 8 ten thousandths in a machine that was originally guaranteed to .0003″, assuming reasonable care has been taken in maintaining a state of cleanliness.

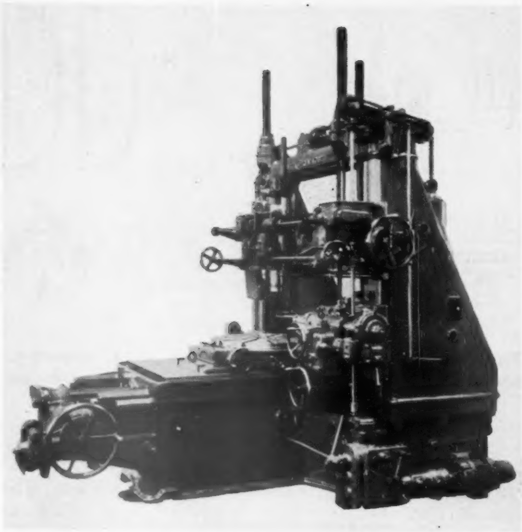


Fig. 5. Large three co-ordinate jig boring machine first built in 1933.

The three co-ordinate machine was first produced as a three spindle machine in 1930 and a few of this model only were made. This machine had one vertical spindle and two horizontal spindle heads which could be raised up the columns by means of a micrometer lead screw. In order to keep the loading on this lead screw to a reasonable figure, the heads had to be partially counterpoised. The excess of spindle head weight over that of the counterweight was made equivalent to the normal load between nut and screw for the other elements of the machine. It will be realised that too little load between the nut and lead screw flanks would result in instability of settings. Too great a load would also result in poor settings as well as rapid wear.

The Large Three Co-ordinate Machine

It was in 1933 that the large three co-ordinate machine was produced and this machine, a considerable number of which were made, had a main and high speed vertical spindle mounted on its cross-beam spindle carriage and a horizontal spindle head with approximately twelve inches of quill travel mounted on a carriage on the right-hand column. The carriage could be moved up and down under control of a lead screw and micrometer drum equipped with a pitch correcting device.

On the left-hand column was mounted another carriage which had a counter-bearing bracket mounted upon it. This carriage could be raised up the column face and could be aligned by means of an optical device with the previously positioned horizontal spindle. This enabled long boring bars to be utilised in a manner similar to that used on the conventional horizontal boring machine.

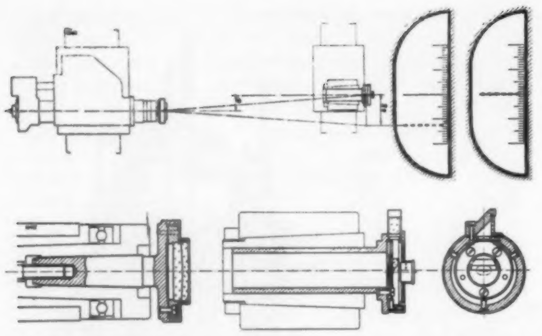


Fig. 6. Optical alignment device to align supporting bearing with horizontal spindle axis on three co-ordinate machine.

The optical device was composed of an illuminated graticule housed in a tubular housing which could be mounted in the outboard bearing. The image of this graticule was viewed through an eyepiece, also co-axial with the outside diameter of this tubular housing, after the image had been reflected and focused by means of a lens system and reflecting mirror mounted in the taper bore of the horizontal boring spindle.

It was possible in this manner quickly to effect a good alignment with much greater precision than can be achieved by other means. The system is still used on the large three co-ordinate machines which are being produced today.

Concurrently with the development of the large three co-ordinate machine, considerable thought was being exercised to overcome the difficulties encountered in making a combined boring and milling machine of high precision. As already touched upon, one of the main difficulties lay in the divorcing of the measuring system from the table and spindle head feeding mechanisms. The idea was finally adopted of utilising much the same means as had been used in the final calibration of the screw type of machine, i.e. the line standard scale and micrometer microscope.

The adoption of this scheme brought a number of major advantages among which were the following:—

1. the standard scale and micrometer microscope which had hitherto been the means of finally inspecting and standardising the screw type of machine, and which was of a higher order of accuracy than these machines, was now to be the built-in measuring system of these new machines;

2. the standard scale provided a permanent unwearing standard of measurement when used in conjunction with the heavy duty optical system provided;

3. the scale, which is of small mass and composed of a material which has the same coefficient of linear expansion as the cast irons and steels utilised in the construction of the rest of the machine, was so built into the machine that it was not subject to rapid changes of temperature.

This stability was achieved as a result of surrounding the scale by heavy masses of material and is a very very considerable factor when considering the overall accuracy of the machine.

4. The measuring system was completely insulated from any stress even during heavy milling operations.

In conjunction with the optical measuring means the designers decided to provide an infinitely variable traversing mechanism to the main table of the machine, thus providing suitable milling feeds as well as a fast traverse for rapid movement from one setting to another. This was achieved by means of a well-designed hydraulic system which had some ingenious features. The ram of the hydraulic cylinder had a short length of lead screw cut in it at its outer end and the nut on this lead screw was carried in bearings mounted in the front end cover of the table.

The front end of the cylinder also carried a unit composed of a special split bushing surrounding the ram and which could be closed down to lock the ram in any position when hydraulic pressure was admitted to this unit. A flexible leather sleeve round the split bushing closed it when oil pressure was admitted between this sleeve and the outer casting. The pressure was admitted to this locking unit when the lever operating the table hydraulic traverse was in its neutral position.

A suitably placed fine feed handwheel enabled the table to be moved relative to the locked hydraulic ram by rotating the nut on the fixed lead screw when making settings. When the setting had been achieved the operation of the table clamping device automatically cut the hydraulic pressure from the locking unit, with the result that any further rotation of the table setting handwheel did not result in a movement of the table. This constituted a very useful safeguard against the possibility of spoilt work due to someone inadvertently moving the handwheel after a setting had been made.

The hydraulic tank and pump unit was housed well away from the measuring system and the tank and piping were adequately insulated, so that the small rise in temperature associated with all hydraulic systems would have no effect on the precision of the measuring system.

The spindle carriage of this machine was traversed by a lead screw and milling feeds were provided by means of a small built-in electric motor.

Anti-friction Bearings

For the first time, anti-friction bearings of sufficient accuracy had been specially developed for this machine. Such was the precision of these bearings that it was possible to guarantee that the concentricity of the spindle nose taper would run true within 1μ or .00004″ with interchangeable sets of bearings.

As a matter of interest, although considerable assistance was given by a famous ball and roller bearing manufacturer in the making of the first sets of bearings, ultimately they declined to continue to make them on account of the very great difficulty of manufacture. The makers of the jig boring machine therefore developed a special department for the

manufacture of these bearings, the quality of which has increased year by year as experience has been gained and special grinding equipment developed to finish the track surfaces and taper roller diameters.

Machinery has been developed that enables the track surfaces internally and externally to be ground to a finish of less than decimal 24 of a micro-inch.

It has been found that with a special grease these bearings will run without any attention for many years. One company has recorded 40,000 hours without attention and the bearing is still in service.

The quill of this machine was made from nitralloy and it was counterbalanced in an ingenious manner. The counterweight was supported in such a manner that in addition to counterpoising the weight of the spindle quill, it also relieved some of the spindle head carriage weight from the crossbeam guideways. This, of course, improved the ease of setting and reduced the bearing load on the ways with a corresponding reduction in the rate of wear.

The spindle, being equipped with anti-friction bearings of high precision, could be rotated at much higher speeds than had been the case with the earlier plain bearings and, as a result, it was possible to dispense with the auxiliary high speed spindle with which the earlier machines had been equipped.

A considerably more comprehensive spindle head was designed for these machines, providing six rates of feed in either direction with an adjustable automatic tripping device to cut off the feed at predetermined positions along the quill traverse. The excursion of the quill had been increased to ten inches and this resulted in a long quill with a correspondingly larger spindle head. One result of this increase in size was the inability of the operator to reach the upper end of the spindle to tighten the draw bar holding the tools into the taper nose of the spindle.

An arrangement was therefore provided which enabled the draw bar to be locked to the spindle head casing when the spindle quill was raised to the higheat position. The tool could be clamped or ejected by an appropriate rotation of the tool and spindle around the stationary drawbar.

A Great Advance

The features just described, together with many others, represented in 1934 when the machine was first offered a very great advance on anything that had been available up to that time. Very shortly after its introduction it became apparent that the new combined boring and milling machine had outgrown the name of jig boring machine, as its field of usefulness embraced the production of prototype machine parts, as well as the direct economic production of batches of components of a precise and intricate nature. So advanced was the design that right up to 1952 the machine was still being manufactured with only minor modifications and refinements.

The next phase in the development of the planer-type jig boring machine was concerned with the gradual increase in the rigidity and ease of operation of the screw type machines. Those machines which had been equipped with plain spindle bearings were redesigned, incorporating much of the experience

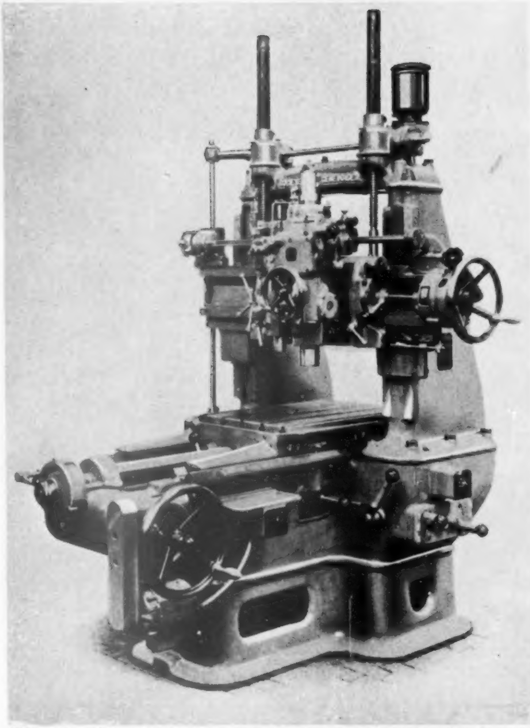


Fig. 7. More rigid machine of the 1934 period, with motorised elevating of crossbeam and table rapid traverse.

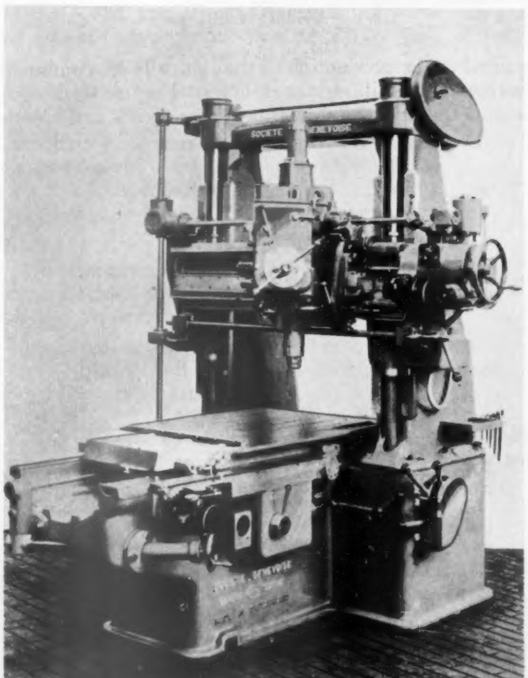


Fig. 8. Combined boring and milling machine with optical measuring system and hydraulic milling feeds to table.

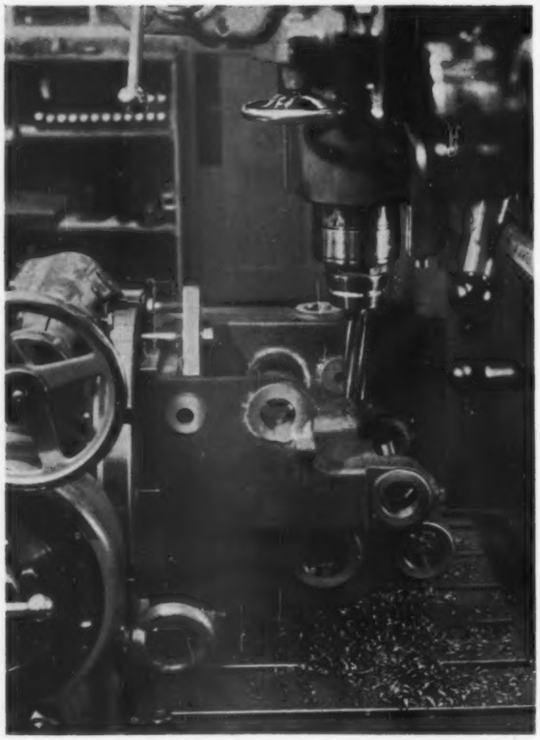


Fig. 9. Typical workpiece completely machined on combined boring and milling machine using inclinable dividing table.

gained in the production of the optically set combined boring and milling machines. The new designs included anti-friction bearings, more feeds and speeds and the motorisation of table and spindle carriage motions with the necessary safety interlocking devices. Built-in depth measuring devices were provided on the spindle heads of these machines to facilitate the rapid and precise machining of ball-bearing housings, etc., to be found on prototype or batch production work.

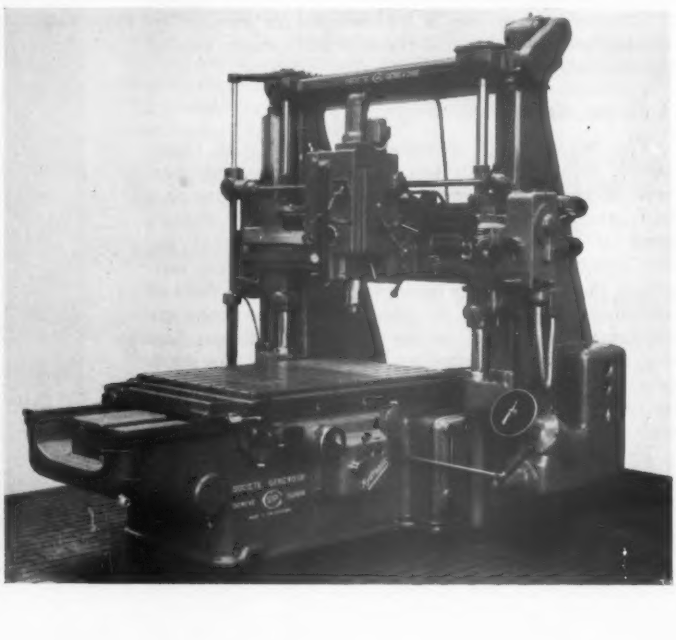
Right up to 1938 the largest of the machines was still a lead screw type machine, but due to the ever increasing size and weight of work-pieces that the users wished to machine on the jig borer, it was considered time to produce a machine of some 60″ x 40″ co-ordinate capacity incorporating all the experience gained to date.

It had been found that as the weight of the work-table and work-piece increased, there came a point at which settings became difficult due to the effort needed to traverse the table along its guideways. Increasing the surface of the guideways to reduce the bearing load per square inch did nothing to reduce the setting difficulty. The new large machine was therefore equipped with a roller type of vee and flat guideway. This was effected by utilising hardened hollow rollers, whose diameter was very slightly greater than their length, separated by carefully made cages.

In the vee way the rollers are arranged with their rotational axes alternately at right angles and the moving table has an inverted vee guideway machined in it to locate over the rollers. The flat way has rollers of the same dimensions held in a suitable cage. This construction enables the ways to be handscraped and optically measured for curvature in exactly the same manner that had been found necessary in the construction of machines of this accuracy.

The heavily loaded table was found to be so easy to move that if the hydraulic cylinder were uncoupled the table would slowly move to one end of the bed if the machine were out of level by as little as 20 minutes of arc.

Fig. 10. Prototype of large combined boring and milling machine produced in 1938.



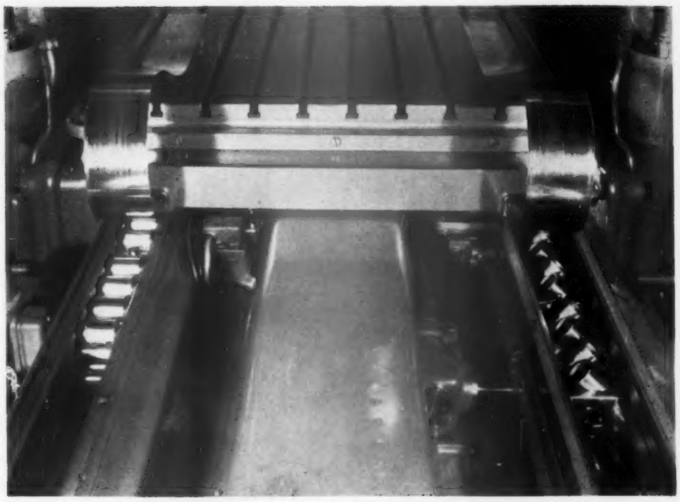


Fig. 11. Roller type vee and flat way on large heavily loaded jig boring and milling machine

In fact, on account of this extreme freedom of movement an entirely new table clamping device had to be developed, as it was patently not possible to lock the table by clamping it down to its ways in the normal manner on account of the presence of the rollers. The manner in which the table was locked finally subjected the rollers to no stress whatever, although the table was firmly restrained from movement along its ways.

A thin steel plate, the length of the work-table, was attached by a number of screws and dowels to the table along one of its edges. This plate fixed in this manner had flexibility in a vertical direction, although on account of its length and manner of attachment to the table it had great longitudinal stiffness.

The unsupported edge of the plate was made to pass through the jaws of a powerful clamping device attached to the bed of the machine. In this manner the table could be clamped without load on the rollers or deformation of the table.

An Interesting Safety Factor

An interesting safety factor was incorporated in the roller system to prevent any accidental vertical overload or shock load from causing indentations of the vee guideways by the rollers. This has been effected by making the distance between the lapped end faces of the rollers a calculated amount smaller than the diameter in order that an overload will cause the hollow roller to deform elastically, thus transferring the load from the normal line contact to the greater load-bearing end faces of the rollers.

The roller construction has a number of advantages apart from that concerned with delicacy of setting, the most important of which is, of course, the fact that this type of slide is virtually free from wear.

In the course of development the framework of the machines had become more and more rigid to enable heavier machining cuts to be taken, and this had resulted in the vertically adjustable crossbeam and spindle carriage unit becoming very heavy indeed. In fact, on the machine which is being described, the crossbeam assembly weight had reached a figure of three tons, which the designers considered too much to be elevated with precision upon two matched elevating screws in the manner which had previously been utilised.

They therefore introduced a system whereby the crossbeam weight was completely supported by a pair of hydraulic rams during the time that the elevating screws were rotating. The sequence of operations when the crossbeam elevating lever was moved was as follows:—

1. four preset spring-loaded clamps, holding the crossbeam to the column faces, were hydraulically unloaded;

2. the hydraulic pressure in the rams built up to sufficient pressure to raise the crossbeam by the amount of backlash between the elevating screw nuts and the elevating screws, thus relieving the precision supporting flank of the elevating screws of all load;

3. at this pressure a manometric switch cut in the elevating mechanism motor and two screws turned in unison and moved the crossbeam;

4. on release of the operating lever it returned to its neutral position and cut the elevating motor whose electric brake automatically came on;

5. the pressure in the two supporting hydraulic rams was permitted to fall, allowing the weight of the crossbeam to rest once more on the supporting flanks of the elevating screws and level itself off to the table surface.

6. The pressure in the clamp releasing units was permitted to leak away slowly to drain through a check valve, so that the clamps came on again a second or so after the beam had found its new position.

This system prevents the important flanks of the elevating screws from wearing at all, as these flanks are actually separated during movement of the crossbeam.

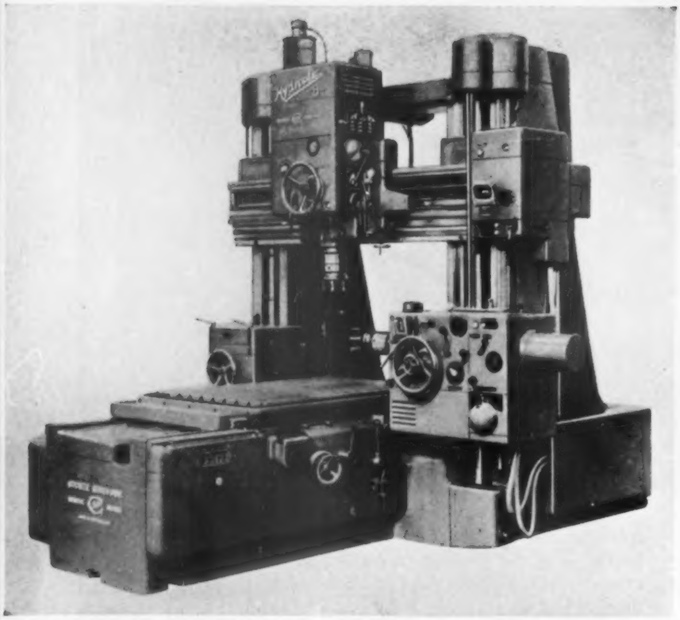


Fig. 12. Modern three co-ordinate combined jig boring and milling machine weighing approximately 14 tons.

The machine which is being described, and which was completed and exhibited in 1939, had in addition to the features just mentioned a great number of other refinements intended to increase the ease with which the machine could be operated, bearing in mind that on a machine of this size some form of remote control is essential, as the machining point can be as much as six feet or so from the normal operating position. The spindle head which could be operated from both sides was equipped with a rapid motion to the quill controlled from the operating position.

There was also a preselecting type of speed change device which enabled the operator to select the next speed required while still running at the already set speed and to engage the new speed simply by the movement of the clutch lever.

An extensive electrical and mechanical interlocking system was provided to prevent damage through faulty operation or accidental overload.

This machine was purchased by a prominent concern in this country with the result that, all during the War years, the manufacturer was unable to study its performance and consequently developed another big machine which utilised rather more electrical control than the previous prototype. It was as a result of experience with this machine that in 1947 and 1948 two more large machines were developed and made available to industry generally. Both these machines were of similar construction, although the later machine is a three co-ordinate machine weighing over fourteen tons. The main features of these machines can be summarised as follows:—

Measuring System

Standard Scale and micrometer microscope to table, vertical and horizontal spindle head carriages. The latest machine has projection-type translucent screens instead of the micrometer microscope.

Table Traversing Mechanism

Hydraulic cylinder, table moving on rollers, fine feed for setting operated by push-buttons from three stations round the machine.

Vertical Spindle Head Carriage

Traversed through lead screw and electric motor, three milling feed in other direction and a rapid traverse. Fine hand-feed for setting.

Cross Beam

Counterpoised beam, automatic cycle of unclamping movement and clamping from single operating lever.

Horizontal Spindle Head Carriage

Traversed vertically by means of rotating nut on lower end of the left-hand crossbeam elevating screw. Weight of carriage counterpoised and automatic cycle of unclamping movement and reclamping from single lever.

Vertical and Horizontal Spindle Heads

These spindle heads were of monobloc construction incorporating their own motor drives and change speed mechanisms. They were provided with built-in depth measuring devices, rapid quill traverses, and were arranged automatically to change the final drive to the spindle from a gear drive to a vee-rope drive at the higher speeds to permit of borizing with diamond or carbide boring cutters.

There are, of course, a great many other interesting devices, both mechanical and electrical, incorporated in these large modern combined boring and milling machines, each one of which would merit a discussion as long as the whole of the present Paper.

In concluding this Paper, the Author once again would draw attention to the utter impossibility of dealing in any great detail with the innumerable aspects which could be considered covered by the title. It is hoped, however, that the brief history included, together with the subsequent rather inadequate technical descriptions, will at least serve to interest the novice, to whet the appetite of the student and provoke a lively discussion among those interested in this absorbing subject.

Acknowledgment

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WHAT IS GOOD DESIGN?

by Sir WALTER PUCKEY, M.I.Prod.E., F.I.I.A.

President of the Institution.

An Address presented to the Scottish Design Congress, May, 1954.

"AESTHETIC aspects do not enter into our design considerations." These words, taken from a recent letter by a senior engineering manager, illustrate the gulf that still exists between the so-called Engineer Designer and Artistic Designer, a gulf that is probably wider in engineering than in other industries. The engineer is traditionally one who governs his dimensions and shapes by two considerations—calculation and "looking right". Mechanical sciences determine so many engineering dimensions, and what is outside their precise sphere is usually determined by that inner feeling of the engineer which tells him that the shape looks right.

Let us pause awhile and ask ourselves whether we can place great faith on this self-stated ability of the engineer to "feel" that the shape is right. Fig. 1 shows us a machine tool designed over twenty years ago, and Fig. 2 the same type of machine today. There is not a great change in shape, but there is much change in mechanical design and efficiency. Fig. 3 shows an aeroplane of the last War with Fig. 4, its latest counterpart. Here we have a great difference in external shape, as well as a great change in mechanical design and efficiency. Many of the same men were concerned with both earlier and latest designs, but over the years their conception of the "right shape" has undergone change. Fashion and technological change have played their parts in bringing about a new shape concept.

What right has the engineering designer to say that he can keep as up-to-date in his artistic appreciations as in his functional designs? His answer would be, generally, that he designs largely for fellow engineers, and by taking in each other's washing they under-

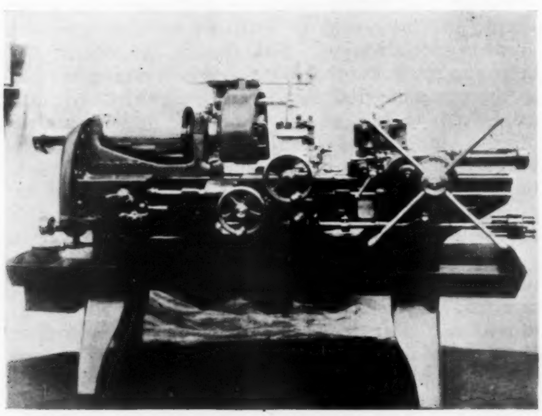

Fig. 1. A machine tool designed over 20 years ago.

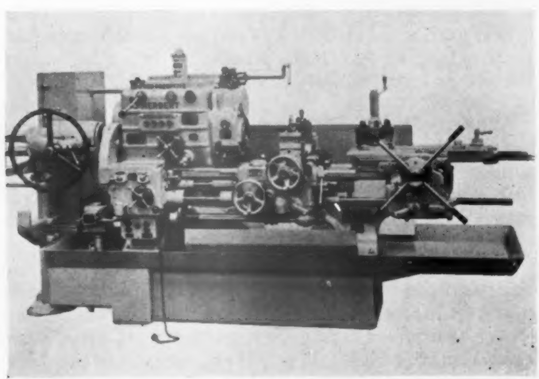

Fig. 2. The same type of machine today.

Fig. 3. An aeroplane of the last War.

Fig. 4. The modern counterpart.

stand each other's standards. But this is getting less true as more engineering enters our lay life, and mechanisation spreads its blessings and problems over an ever-widening circle of people.

Machines of all descriptions invade offices, factories, homes, air, land and sea, and we must not exclude the mechanisation of the Services, because here, too, design plays a great part, and not solely for killing. More money is spent on designing equipment used in the Services than in any other industry, and the aircraft example recently quoted is appropriate to stress here, as the aeroplane, dominant in war, is taking over more of the world's transportation, and those designs prepared for war are often adapted to civil requirements, where artistic merit is worth something.

I showed in Fig. 4 a modern British bomber compared with its war-time predecessor. In Fig. 5 we see another modern British bomber, designed largely to the same specification as the Vulcan, and in Fig. 6 a corresponding modern American bomber. Here you see major variations in external shape. The two British planes are quite different in outline from each other, and in the American bomber we see the engine pods extending like floats instead of being buried in the wings—a considerable design and shape change.

What do these further examples show us? Surely that we can have major shape variations in achieving similar functional standards, and that over relatively brief periods of time what looked the "right shape" may, through the same eyes, be quite the wrong shape.

Lucky, or highly skilled, is the man whose design has stood the test of time, both in aesthetic and functional value, and an interesting case is the Rolls-Royce radiator (Fig. 7) which, designed fifty years ago to achieve high functional efficiency, has retained that virtue and also become accepted as an aesthetic hall-mark.

I have already used the terms "aesthetic" and "functional" several times, and it is hardly necessary to say that there are broadly two groups of designers, each overlapping the other, each with fairly clear spheres of responsibility, training and experience. Both terminology and co-operation have been faulty and too often those in one group are not on the closest of terms with the other. The lay person is even more confused, and can be pardoned for not realising what sort of person and responsibility is framed by the term "Industrial Designer", which is, incidentally, a misleading term.

I, as an engineer, recognise the two groups by the following names:

Engineer Designer;
Style Designer;

and in doing so recognise that the engineer may appreciate good style and the style designer may be something of an engineer. I suppose that our ambition should be to combine the qualities into one person—each absorbing the other's special knowledge and flair. A happy solution—but I am afraid too simple in this world of intricate mechanisms and greater specialisation. But this is no excuse for failing to recognise that both have something to offer to the complete design, and if I judge my own task aright it is to look at this "complete design" and to offer to you a list of considerations which must, individually and collectively, be taken into account as a basis for achieving it. May I approach this task by saying to the Engineer Designer that no design is complete without serious considerations having been given to style. To the Style Designer may I say how lucky you will be to find an engineer, even a managing director, who recognises your claim to early consultation in the interests of achieving the Complete Design. Marcus Fabius Quintilarius said in A.D. 70 that: "the product without art has a value, with art added the product has a greater value". The modern version is in the Jaguar slogan: "Grace—space—pace".

What is a Complete Design?

In all periods of history goods have been successfully sold which have had little real value, and the good salesman can truthfully say that he will sell anything. But for how long? The answer is always "for a short time only". In the long run it is always quality of some sort that sells the product, and that quality will invariably be found in the product itself. When we talk of quality we often associate it with such names as Rolls-Royce, almost an absolute standard in engineering circles. But there are hundreds of fine examples in this country, many of them in the sphere of quantity or mass-production products, which few laymen regard as promising for the output of quality goods. I hope I am not being a heretic when I say that there may be even greater design quality in a mass-produced inexpensive car than in the most expensive custom-built job, and I say this because wider consideration is likely to have been given to the former, and often a greater risk taken in launching the final design and its manufacturing programme. The Complete Design is a wide concept, extending far beyond the designers, even if they must ultimately put into shape and size what is collectively agreed as a specification and programme.

Let us have a shot at putting down a list of major considerations affecting the Complete Design. One suggested list is shown in Fig. 8,* and I would like to spend a few minutes summarising these before I consider each in detail:

(1) *Technical Excellence*

This means what it says—the fitness to perform its function, such function or performance having usually been laid down in broad terms by the Board or some higher authority. This, on our stage, is the principal character around which we shall place our supporting cast.

The departments principally concerned are:—

(*a*) Board of Directors (or equivalent);
(*b*) Engineering Design.

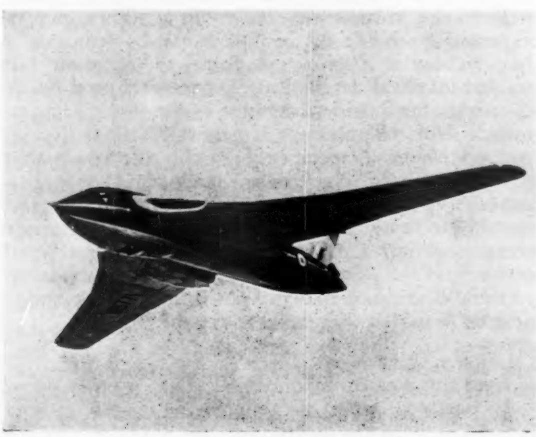

Fig. 5. A modern British bomber.

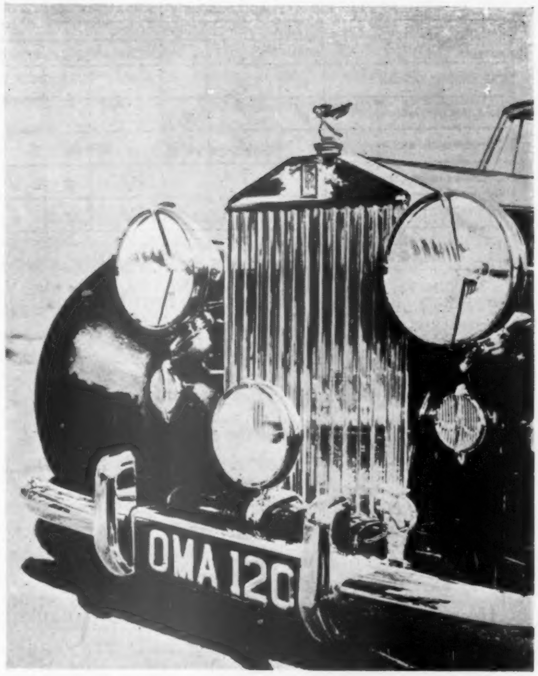

Fig. 7. Radiator of the Rolls-Royce motorcar.

(2) *Attractive Appearance*

It is no accident that causes me to place this second on my list; in fact, one might call it the leading lady. I have already said that good style is essential to the Complete Design, more necessary than ever when our products are widely dispersed among, and used by, the many. If we accept this view, then the sooner style is considered and embodied in the basic design

Fig. 6. A modern American bomber.

*I. F. Kinnaird, " Machine Design ", June, 1953.

MAJOR CONSIDERATIONS AND DEPARTMENTS AFFECTING THE COMPLETE DESIGN

CONSIDERATIONS	DEPARTMENTS					
	BOARD	ENGINEERING DESIGN	STYLE DESIGN	PRODUCTION	SALES SERVICE	FINANCIAL
(1) TECHNICAL EXCELLENCE	✓	✓				
(2) ATTRACTIVE APPEARANCE	✓	✓	✓			
(3) MECHANICAL NICETY		✓	✓	✓	✓	
(4) SUITABLE PRODUCTION COST	✓	✓		✓	✓	✓
(5) AVAILABILITY AT PROPER TIME	✓	✓		✓	✓	✓

Fig. 8.

the better for all. Those departments principally taking part are:—

(*a*) Board of Directors;
(*b*) Engineering Design;
(*c*) Style Design (internal or advisory).

(3) *Mechanical Nicety*

This is the short phrase covering several essential requirements of which the following are important:—

(*i*) detail design;
(*ii*) quality control;
(*iii*) export requirements;
(*iv*) ease of servicing.

How often have these details let us down, particularly in overseas markets?

Those departments principally taking part are:—

(*a*) Engineering Design;
(*b*) Style Design;
(*c*) Production;
(*d*) Sales/Service.

(4) *Suitable Production Cost*

Production cost is broadly defined and bears a fairly fixed relationship to customer cost. There are flaws in this argument, but for our purpose it is true enough to assume that in any given industry the total cost structure is built up using production cost as a foundation. This is hard on the production men, but they are used to it.

Many design problems must be considered in setting production cost. Here are some:—

(*i*) price limits;
(*ii*) how many to make, including spares?
(*iii*) time;
(*iv*) availability of new materials and processes;
(*v*) increasing complexity of customer requirements;
(*vi*) high cost of productive facilities.

Truly a wide consideration likely to involve the following departments:—

(*a*) Board of Directors;
(*b*) Engineering Design;
(*c*) Production;
(*d*) Sales/Service Department;
(*e*) Financial Department.

(5) *Availability at Proper Time*

You might well say that this is a function of (4) where I refer to Time. It is, however, worth a special place if only because right timing is likely to be more important to us in the competitive world of tomorrow, and more difficult to achieve in face of technological complexity.

Its successful realisation is, I believe, primarily the responsibility of these Departments:—

(*a*) Board of Directors;
(*b*) Engineering Design;
(*c*) Production;
(*d*) Sales/Service;
(*e*) Financial.

So much for our brief analysis, which shows us how broadly based our problem is, and how the Complete Design is a matter, not for one group only, but for many in close continuous collaboration.

Now let us discuss each more fully:

(1) Technical Excellence

(*a*) *Basic Specification*

The basic specification is an extremely important document. It can be a complicated, long statement involving mathematical or scientific precision, or, as is surprisingly frequent, a simple document which, by its simplicity, hides the great thought that has gone into the essence that is finally put to the designer. The Ten Commandments and Newton's Laws of Motion are simple statements embodying great thoughts. Two engineering examples are worth quoting. The first is a bomber plane where the specification could be summarised in the words of the Company's advertisement—"Fastest—farthest—highest". This, for obvious reasons, is an over-simplification, but illustrates the principle. The second case concerns a well-known washing machine where the original specification contained three sentences—i.e. the machine must—

(1) wash clothes better than any competitive machine;
(2) fit under the average kitchen draining-board when not in use;
(3) sell (retail) at no more than £x (excluding tax).

Rightly, such specifications give great discretion and opportunity to designers and producers, and the more the basic specification provides a series of guide-posts to define the area of requirements, and the less it connects those posts with barbed wires, the better.

But, and this is important, no designer can be expected to define his own area, and Requirement No. 3 in the washing machine specification just quoted involved detailed market research and policy discussion far outside the range of the design department. Not enough care is generally taken in preparing this basic specification, with the result that many subsequent changes are made, involving compromise, poor detail design, expense and delay. The trend of technological advancement means that more complex designs are inevitable, and while it is difficult to be right the first time, there is plenty of evidence to show that more thought put into the basic specification would be handsomely repaid later on.

(*b*) *Fitness for Purpose*

Does this sound obvious? Actually it often seems to be partly forgotten, particularly where the product is not strictly in the utilitarian class. Let us take the washing machine example again, and consider

Requirement No. 1—"Washes clothes better than any competitive machine". This is its basic task. All too often we see examples in many fields where the *basic* task—washing, cutting, bombing, carrying, seems to be subordinated to mere cleverness of form, to copying of older competitive models, to gadgeteering and, in some well-known cases, to the company's view that it must "make *something* in this line" to complete its range. There are many badly designed articles that are often kept alive by artificial respiration, and could not face the challenge—"are they by comparison really fit for their purpose?".

(*c*) *Improvement over Company's Previous Products*

Change is increasingly expensive, and increasingly necessary as greater research and competition throw up new possibilities and new challenges. Most designs have what we call "stretch" in them, that is, a capacity for improvement to the basic design, and this factor of stretch is very important as a design consideration. Quite often it involves external or style change rather than internal or functional re-design, and to embody the greatest "stretch" in a new design calls for considerable co-operation between the two groups of designers.

Another important consideration is the *long-term* design policy. Happy the Company that controls its own design policy and, in passing, it is usually the best agency to do so. The more it has a long-term design approach, the more it will control its own future. Somebody, even if only one person, should have a telescope and peer at least ten years ahead into the wide horizon, getting ever wider as new technologies, materials and uses come to light in confusing abundance. This capacity for change is one of the significant trends of the age, and a recent American study has shown how the character and products of many large corporations have greatly changed over the years, often because *new* challengers have sensed the future more accurately and provided new products to match it.

(*d*) *Improvement over Competitors' Products*

"Keeping up with the Jones's" applies also to industry, and I suppose that more companies re-design because of competition than because of their own basic policy. Some industries are notorious for frequent competitive change, and before the war the radio industry was a typical one. I have seen complex mechanisms rushed into production to satisfy a sales manager who had read a competitor's advertisement. I saw the same unit scrapped shortly afterwards, for the same reason. Perhaps this is understandable in a new industry, and if we are to capture dollar markets where this attitude is strongly developed we must be prepared to re-design more frequently. And yet I have the strong feeling that good basic design can avoid much panic action, and there is an impressive list of world-beating products to back me up. Many of these products are changed only at infrequent intervals, often extending over several years, but when a new design is launched it has back of it the long-term consideration mentioned in the previous section—a Company-controlled design policy.

One last comment—how much do you know of competitive designs? I have been surprised at the lack of this information in many companies, and it seems worth while having on the Board's agenda at regular intervals a summarised statement showing how you compare with those in the same field.

(2) **Attractive Appearance**

(*a*) *Who is to Decide?*

I asked earlier whether the Engineer Designer was qualified to express sound views on style. "I don't know anything about art, but I know what I like" is the phrase many of us use, but is that enough? I asked a well-known painter recently what was the best way to appreciate good art. He said, "By living with it". This he amplified by asking me what was the best way to learn the French language. I said, "By living in France". "Exactly", he said.

A real contribution to national culture is to surround ourselves with many examples of design which are functionally and aesthetically good. I, as an engineer, am prepared to admit that my engineering ability is greater than my artistic perception, and in realising this I recognise that there are others who, by instinct and training, can make up my deficiencies. To me the problem is as simple as that, and provides one answer to the question I posed earlier—"How competent is the Engineer Designer in the determination of style when this is not dictated completely by calculation?" My answer is that he is not necessarily so, and as the Complete Design requires both qualities we should be wise to recognise the joint responsibility.

Many firms employ their own Style Designers, but it is well known that consultants are also largely used. One difficulty is that while the layman will usually bow to mechanical complexity because he can't understand it, he can be violent in his aesthetic views, a condition which does not favour delegation of style to a third party.

I suppose that the Council of Industrial Design is thought by the majority to be concerned largely with non-mechanical considerations and products, and even I, a believer, recently said to my secretary that "the Council's publications seemed to deal more with teapots, cups, saucers and furniture than anything else". "Why not?", she said. "They are the things in most common use." That is a good way of looking at the future. Engineering products are getting more widely used and operated, and we will live with mechanisation to an ever-greater extent. Let us then live with as many aesthetic satisfactions as possible, so that, as in learning French, we absorb beauty of line by example.

Before closing this section I want to retreat and to enquire, in sorrow, why, with so much concentration on aesthetically satisfactory teapots, one can find so few that give functional satisfaction. I could be very rude on this point, but perhaps it is a warning that achieving the Complete Design is essentially a combined operation, and if we are to recriminate, the Style Designer should probably take some of the blame he often thrusts upon his opposite number.

(*b*) *Improvement over Existing Products*

Much of the comment made in the section dealing with Technical Excellence applies here also. I will again stress the term "stretch", if only because there is often great virtue in buying a new hat instead of re-equipping the whole wardrobe; or in putting a new package around the same contents. Greater design stretch can be frequently achieved through style changes, and to allow for these trends, much skill and co-operation must take place as early in the design process as possible. It is certainly as difficult to forecast style change as functional change, and this should be borne in mind when setting up a long-term design programme.

(*c*) *Capacity to Absorb Design Changes*

Newton said that "the tendency of a body is to continue in a straight line unless impelled by an external force". In other words, bodies, including human, resist change and the good designer recognises that the public will absorb only so much at once. Therefore, like the good general, who while in the lead doesn't lose sight of his troops, the designer doesn't lose sight of his public's inertia.

Examples such as excessive streamlining, the rear-engined car, yes, possibly the Comet, come to mind as cases where the first efforts failed to get adequate acceptance. In the field of personnel relations we now endeavour to explain a new situation to a man in terms of his own experience—we start off from something he has already experienced and accepted. So, in the field of design, we should remember this link, and while no designer should feel restricted on this account his colleagues must consider whether the jump ahead is too great to be made all at once, or whether the full design should be achieved by stages of stretch.

(*d*) *Ease of Production and Servicing*

The first is considered more often than the second. Style often plays an important part in servicing techniques, as car-owners know well. If a choice is inevitable I would vote for easy serviceability rather than style, but surely such a decision is rarely necessary and many examples show that we can achieve both.

With exports in our blood we should really study automatically the needs of foreign customers, but recent experiences have convinced me that we still too often forget that servicing may have to be carried out under less favourable conditions than we think, and this cannot be stressed too much.

In considering serviceability of the product human reactions should be considered, and we should realise that pride is a natural instinct and should be encouraged. The makers of one car I possessed told me in the service manual that "a clean car runs better", and I believe them. Let us encourage finishes, contours and shapes that can be kept easily in good condition, not like, for instance, some domestic products where the so-called wrinkle finish adopted a few years ago certainly hid metal blemishes, but provided thousands of little dust-pockets.

The style designer can contribute much to ease of production, but this means close collaboration, particularly where such processes as sheet metal working is involved, so that problems such as plant and labour capacity and weld lines can be borne in mind. Another important consideration, particularly on a large product, is its division into logical sub-assemblies to help both production and servicing. A modern fighter aircraft comes to mind as an example, where, owing to internal intricacy of design, a maximum of *sub*-assembly and a minimum of *final* assembly man/hours must be achieved.

(3) Mechanical Nicety

(*a*) *Detail Design*

There has been a shortage of good draughtsmen in recent years, resulting in much poor detail work. Someone has said "the drawing-board is the cradle of production costs", and too often the production engineer holds the baby. Details such as dimensioning of drawings, limits and fits, standardisation of materials and parts are vital to the Complete Design, and they receive less than enough attention in colleges and offices.

We know much of the term "designing for production" and the Drawing Office must take prime responsibility, helped by the production people who in some companies have representatives working closely with the Drawing Office, these being changed now and again to avoid contamination. It is too much to expect that every product draughtsman is a good production man, but he can be helped by close and continuous consultation. I remember hearing a well-known aircraft designer say that having been promoted to Managing Director, he now regards himself as a representative of the *Production* Department when he visits the Drawing Office.

(*b*) *Quality Control*

Quality standards are determined at the design stage and embodied in the various parts and assemblies by the Drawing Office, later to be interpreted and applied by the Production Department. Many quality requirements are measurable, others rely more on opinion. Obviously, the better the control the less the area of opinion, and therefore mechanical nicety means as much measurable control as possible. Fortunately progress in metrology and other sciences has broadened the range of precision in measurement, and the Complete Design endeavours to set standards of quality control so that they can repeat themselves within the limits set. Someone once said, "Show me a company whose products are consistent and I will show you a well-organised company".

Allied to this is the question of keeping drawings up to date, and few companies have a good system for ensuring this, which is particularly necessary when spares and service are required far from home.

(*c*) *Export Requirements*

I have just mentioned one of them. There are other problems such as the varying specifications of foreign countries, and occasionally of different areas in the *same* country. Problems of electrical specifica-

tions and standards frequently arise; colour schemes, tropical protection, descriptive names, packing and many others come to mind where troubles have arisen and are likely to continue in a nation like ours, which relies on exporting to live.

One of the best checks is personal follow-up, and fortunately many Britishers seem to be travelling abroad today rather than relying upon customers to come to them. I still smart, however, under the comments made to me last year in Australia when I seemed to them to be complacent about British quality. Mechanical nicety involves adequate control over these foreign requirements, even to the stage of specifying how the product should be packed, something rarely done with enough precision.

(*d*) *Ease of Servicing*

Foreign requirements again come to mind here, and the problem falls under two main heads:

(1) servicing procedures;

(2) spare parts.

Servicing procedure is, briefly, the best means of keeping the equipment running, and the more expensive the equipment the more essential to have it in running condition when wanted. Today we can rarely afford duplicate plant, and the Complete Design must provide procedures which allow for rapid maintenance and replacement of wearable parts, and very often of assemblies such as complete engines, pumps or motors. External or style features must occasionally be replaced owing to damage, and this often involves great attention to colour, finish and shape, so that correct matching can be maintained. Many new finishes fail to satisfy service demands, because of the difficulty of local repairs or replacement.

Mechanical nicety also demands close attention to repair on the spot where facilities are probably poor. Adequate diagrams, understood by simple people, are all too rare. Simple features such as accessibility of essential nuts and bolt-heads and greater standardisation of spanners are frequently missing, and one has the impression that the draughtsmen have never realised or been trained to realise the working conditions of their child.

Spares are not required on every servicing job, but having them on hand when wanted depends as much on the Drawing Office men as on Production Engineers. Standardisation is the keyword, and it involves standards of interchangeability and standardisation of parts and assemblies. I have already mentioned, under Quality Control, the importance of good dimensional control methods and systems, but we often, too, without realising it, put up with excessive duplication of similar parts, and there is great scope for investigation into this. Fig. 10 shows diagrammatically, and among the exhibits you will see physically, what can be done by good control methods which help to eliminate excessive variety, a step forward which helps costs, control and customers.

(4) Suitable Production Cost

(*a*) *Price Limits*

Earlier decisions have probably fixed selling price limits and, working back from customer price we establish (or should do) production cost. In my experience, production target cost and basic specification are not generally as well publicised internally as they should be, and do not get the attention they deserve. There are always people who want to add new features or buy new equipment, and this is good providing it can be done within a target. I am a great believer in targets, and have so often found that if a designer is given both target and encouragement, better results appear. We compromise on design too often, and top managers might more often run the risk of being labelled obstinate or stupid by asking "why" or "why not", when told of technical difficulties that appear to stand in the way of achieving something better for less cost. It reminds me of a "Safety Fast" slogan adopted some years ago. Every time an accident (or near-accident) occurred in the works the job was analysed to avoid another. It was laid down as a target that no job was to be slowed down in making it more safe. "Safety Fast" was the motto. In 90% of the cases greater safety was ensured at *less* cost.

THE COMPLETE DESIGN

Major Considerations	Some Sub-Headings
1. Technical excellence	(a) basic specification (b) fitness for purpose (c) improvement over company's previous products (d) improvement over competitors' previous products.
2. Attractive appearance	(a) who is to decide? (b) quality control (c) export requirements (d) ease of servicing
3. Mechanical nicety	(a) detail design (b) quality control (c) export requirements (d) ease of servicing
4. Suitable production cost	(a) price limits (b) how many to make, including spares? (c) time (d) availability of new materials and processes (e) increasing complexity of customer requirements (f) high cost of productive facilities
5. Availability at proper time	(a) competition (b) political trends (c) economic trends (d) technological trends

Fig. 9.

(*b*) *How many to make, including Spares*

Senior managers frequently do not realise how desirable it is to specify the total quantity to make of a given design as well as the *rate* of output. I admit that this often involves considerable guesswork, but from the production standpoint it makes a great difference. Broadly, the difference between the American approach and ours emphasises one reason for the difference in our respective productivities. If they, for instance, wanted a 100-ton press for an operation on a component they would probably buy a 200-ton

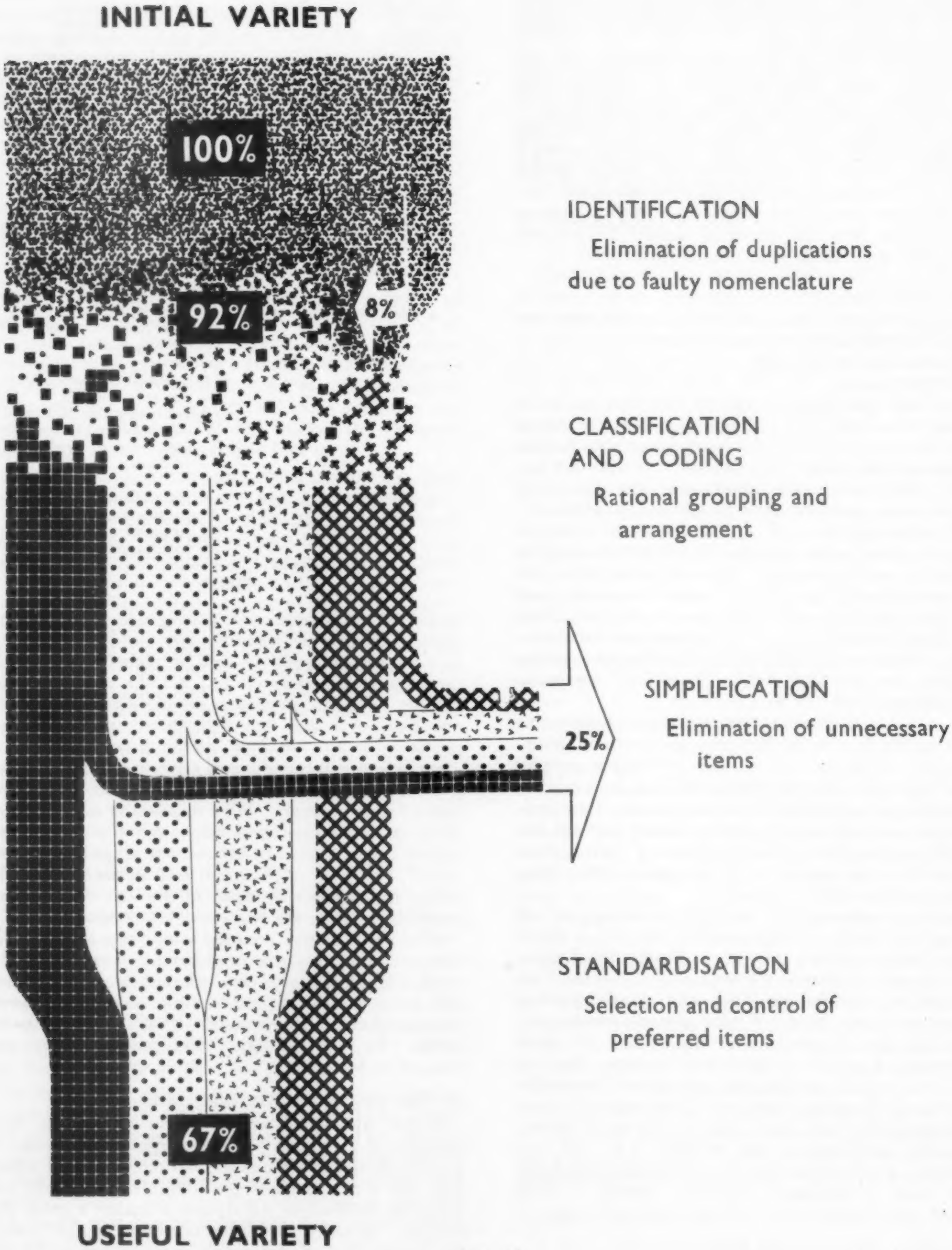
INITIAL VARIETY
100%
92%
8%
IDENTIFICATION
Elimination of duplications due to faulty nomenclature
CLASSIFICATION AND CODING
Rational grouping and arrangement
25%
SIMPLIFICATION
Elimination of unnecessary items
STANDARDISATION
Selection and control of preferred items
67%
USEFUL VARIETY

Fig. 10

press to be on the safe side. We might buy two 50-ton presses, and any production engineer knows the great differences in layout, tooling and productivity this might involve.

A quite different design approach is needed if total quantities to be produced vary considerably. Not only will quite different plant, tooling and layout problems arise, but even the materials and their design may alter radically. For instance, a casting may be better than a pressing if quantities are smaller; abricated construction may be better than casting; machining from the solid may be cheaper to save high tool costs on a small total batch, and so on through many examples.

With *total* production we can logically discuss *rate* of production, which is the actual programme of production. This is not so closely related to Design except in the total period over which total production is spread. If production is completed only against a firm customer's order there is usually less risk of design obsolescence, but many products are made in anticipation of orders, and the period over which total production is spread plays a vital part. Every design is acceptable only within a certain time period, and a simple example is the case of Coronation souvenirs, where total production quantity must involve considerable guesswork and where the product's "acceptability period" is extremely limited.

Several factors affecting the complete design are becoming more prominent, and the following seem particularly important:—

(1) time;
(2) increasing availability of new materials and processes;
(3) increasing complexity of customer requirements;
(4) high cost of productive facilities.

(1) *Time*

I shall deal with this in my final section, and will say no more now except to *underline* its importance.

(2) *Availability of New Materials and Processes*

Britain is research-minded, and has to her credit a long list of notable discoveries, not least in basic materials and processes. Increasing funds for industrial research, together with high government expenditure on defence weapon research, means that ever more new ideas will emerge in future—in fact, if they don't, Britain's place in the industrial world will fast diminish because we must supply the world, not so much with the easy things, but with those containing new and exciting possibilities.

The Complete Design must therefore take full advantage of this research, which means, first of all, better means of keeping in touch with developments all over the world. There is so much available that the sheer administrative work involved is considerable, quite apart from the judgment required to select promising new lines.

Considerable design judgment is needed to use a new material effectively. Cost is an obvious consideration and will be dealt with shortly. Then there is material availability which often involves much guesswork, as statistics of new material production are usually sketchy. The Americans do a much better job here, and examples such as the Paley report and books such as this one on beryllium possibilities *help designers and producers to decide whether, in terms of cost and availability, a new material is desirable to adopt.

I must stress one point here. No designer should be too restricted by economic considerations when considering new possibilities. He will find plenty of others to remind him that they exist, and he shouldn't do their work for them! While he should have some knowledge of the economic facts of life, his job is to present the new possibilities and leave it to colleagues to accept his challenge or to ask for modifications based on other factors.

No production engineer worth his salt would cavil at this view, as he really does, despite appearances, appreciate a challenge to *his own* imagination when presented with a design which calls for new materials and processes.

One last point on new materials. A number of examples shows us that every time a new medium is available, it goes to the head of designers, and we get a rash of products embodying it. The plastic field is an example where some horrible things have been foisted on us in the name of novelty. Perhaps this is inevitable and healthy during a period of experiment with new possibilities, but designers should, I think, pay more than the usual attention to style considerations when introducing new materials.

(3) *Increasing Complexity of Customers' Requirements*

Designs are, in general, getting more complex and this trend will continue. It takes a genius to make anything simple, and there are few around. Most new designs are over-complex, and as new design rapidly replaces new design in this technological world there is less opportunity to simplify, or to re-design for production.

Because world competition demands more frequent change, the Complete Design gets less chance to "jell" and trends of progress become more important. This is where the long-term design programme mentioned earlier is valuable, and real skill lies in anticipating design trends so that they may be embodied with as little inconvenience as possible, not only in new production but often in existing products.

This affects producers as well as designers, because the production plant itself falls into the same category of complexity, high cost and re-design possibilities. Production engineers must, therefore, work in parallel with designers so that the means of production match the design changes.

(4) *High Cost of Productive Facilities*

New materials, processes, designs and plant cost an awful lot of money today, and it doesn't get less. Such a new material as titanium costs millions of pounds to set up a quite small production programme, and even when the material is available, its cost and production difficulties involve serious consideration. In the aircraft industry, production of large integral forgings, a desirable design feature, costs millions in a new plant.

Most companies, under present taxation pressure, find it difficult to keep modern, and investment per head in Britain is too small for such a manufacturing

* Materials Survey; Beryllium, compiled for the National Security Resources Board by the U.S. Bureau of Mines, 1953.

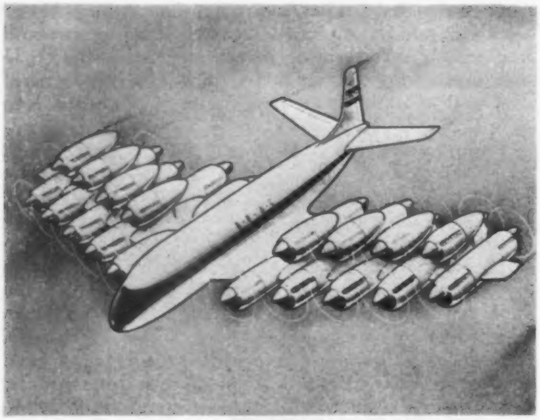

Fig. 11.
Hypothetical piston-engined high altitude airliner.

nation. I forecast little real relief, despite the disappearance of the Excess Profits Levy, and it behoves us therefore to consider costs much more carefully than most nations. This may easily prove our undoing, as it doesn't take long, when freezing investment, to freeze ideas also. Those industries which have a consistent plant modernisation programme have usually a progressive product programme, too.

All parties, in the interests of customer cost, should do much to ensure that when investment in new equipment is needed to produce new designs, both the designs and the plant trends and possibilities should be considered together, so that they can be "stretched" in unison with each other, in the interests of cost and time.

This brings me logically to our final design consideration:—

(5) Availability at Proper Time

Several trends affecting delivery and customer satisfaction are noticeable today. They can be summarised under four headings such as:—

(*a*) competition;
(*b*) political trends;
(*c*) economic trends;
(*d*) technological trends.

Let me say a few words on each.

(*a*) *Competition*

I don't apologise for again mentioning that this is likely to get sharper. The recent American recession and German and Japanese recoveries are appropriate catalysts, and spur us to counter-action. Success will come from success in achieving the Complete Design on more of our products.

(*b*) *Political Trends*

Instability of tenure leads many governments either to do nothing or, much worse, to do too much. In our case, close balance between major political parties has since the war produced a spate of legislation and counter-legislation which hardly creates long-term confidence within industry. Under such conditions industrial progress is often slowed down because full confidence is lacking, which in turn restricts long-term planning of design and production.

In the field of defence, on which over £1,600 million is being spent this year, industry plays an ever more important part in design and production, and political trends can, as they have recently done, upset programmes considerably because it is said that "every weapon in production is out of date". With defence taking such a high percentage of national activity and with almost every industry now contributing to it, this constant search for new designs carries over into civil life a greater atmosphere of change.

Taxation, capital shortages, higher wages and costs combine to underline the importance of higher productivity, and the designer's colleagues may be pardoned for stressing *cost* almost to the point of indecency.

Now costs and times are close relations, much more so than usually assumed, and in controlling cost I start by controlling time. I believe that designers should be better acquainted with time and its importance. Many say that you can't set up a design/time programme—"you can't think by the clock", but I'm not so sure. All designers know that suddenly the idea may float up, but often it is, like the iceberg, that bit on top which is supported by the mass underneath, and having a time target often forces us to concentrate more on the subject, in other words to build up the mass underneath so that the peak emerges more quickly.

The Complete Design should include a time programme for every participating department, and it should be reviewed at regular intervals to give information, encouragement, inspiration and, if necessary, more guidance to Sales people, so that customers may be warned well in advance.

(*d*) *Technological Trends*

Technological trends are making accurate timing of production more difficult and, as said earlier, even more complexity may emerge from more competition, with, paradoxically, competition requiring us to give even more attention to timing and customer satisfaction.

We are faced then with clashing interests, and all parties must co-operate to solve the difficulty. Its solution lies in adequate co-operation and control so that *all* parties are warned in advance and can take early and adequate action. Departments must proceed in "parallel" rather than in "series" so that the period of time involved in "conception to realisation" is minimised. This now takes years with many designs, and I have endeavoured to show the trends which may well have the effect of nullifying the best designs if time is not more closely borne in mind.

No design is of value except in relation to a particular period, and a design produced too late is as useless as a padlock when the horse has gone. Of all the problems besetting us in achieving the Complete Design, time is one of the most important.

Let me summarise:—

I am conscious of speaking as an engineer to an audience whose constitution I do not know, but who by its presence has an obvious interest in good design.

I set out to show that good design is not just engineering or even art—it is the Complete Design, which embodies many considerations and many departments. Only if all of these considerations are embodied will business continue to prosper.

My admission that style plays an important part springs from (*a*) my own limitations as a stylist and (*b*) my belief that we all have a duty, in the worlds of leisure and business, to encourage beauty in its many forms, and only by living with many good examples will we effectively absorb it and spread its blessings.

I will be pardoned for continually stressing the needs of good business. Art in a garret may be good for "La Bohème" and Puccini, but Britain must live by trade, and artistic endeavour may be applied over a wide range of activities, with its results not only in museums and exhibitions, but applied over a wide field in the interests of better living and better business.

I will end by emphasising one final comment on the future. Those in touch with research will know that never have there been so many new inventions and possibilities just over the horizon. Never will there be a more testing time for Britain than the next ten years, when these ideas must emerge in concrete form so that we keep our place in the world.

In this task, greater specialisation is inevitable because of technological complexity. The highest skill will lie in blending the specialists into an integral whole, each working in parallel with his neighbour in the interests of time, each recognising the worthwhileness of the other's contribution, and all co-operating closely and continuously to achieve the Complete Design.

Fig. 12.

ACKNOWLEDGMENTS

The photographs in Figs. 3, 4 and 5 are reproduced by courtesy of "The Aeroplane", and Fig. 10 by courtesy of Mr. E. G. Brisch.

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DEVELOPMENT OF MACHINE PRODUCTION IN THE SHOE INDUSTRY

by J. H. BRITTON, J.P.

Presented to the Western Section of the Institution, 24th February, 1954

Mr. Britton, who was educated at Clifton College and Trinity College, Oxford, joined the family business of G. B. Britton & Sons in 1927. He became Deputy Chairman and Managing Director on its being converted to a Public Company, G. B. Britton & Sons (Holdings) Limited, in 1951.

He is a Past President of the Bristol Chamber of Commerce and of the Boot and Shoe Manufacturers' National Federation, and was elected a Fellow of the British Boot and Shoe Institution in 1953.

He has been a Justice of the Peace since 1945, and is Sheriff of Bristol this year.

Mr. Britton

WHEN your Secretary paid me the compliment of asking me to address you, he suggested "Production Engineering in the Shoe Industry" as a subject. I shied at that, for when I discovered what it meant, it seemed to me far too technical and difficult a subject for a plain business man like myself. So we decided on the present title. I ought to have shied at that too, for the amateur instructing the professional is an even more pathetic phenomenon than the blind leading the blind. However, so long as you realise that I am not an engineer but a businessman possessed of a mind that is more than ordinarily un-mechanical, I will do my best.

Until about 100 years ago boots and shoes were made almost exclusively by hand. The shoe-maker stuck to his bench and his last—and used a hammer, a knife, an awl, nippers, a rubstick, hog-bristles for needles, thread which he waxed himself, and a boot strap. He cut his pegs and skived his leather with a knife and he could whittle his own lasts with it or he could increase their measurement by tacking on pieces of leather, if he was making a pair of boots to a customer's own measure. In the middle of the nineteenth century, however, certain rather rudimentary machines began to be used in America, and in England in 1858 a machine for cutting butts in ranges and another for chopping soles out of the ranges, both worked by treadle, were bought for James Clark of Street (one of the original partners of that well-known firm) by a boot-manufacturer friend in Lynn, Massachusetts.[1] Meanwhile the sewing-machine, invented by Howe in 1846, had begun to be adapted in America for putting uppers together. This was followed soon after by the first attempt at a sole-sewing machine by a Mr. Blake. Mr. Blake was not a practical shoemaker or he would probably have attempted to imitate hand methods of welt sewing or turn sewing. As it was, he took the idea of the ordinary sewing machine and set himself to devising a method by which an arm could

be extended into the shoe to catch the loop of the thread from the needle, passing through from the outside.

After much study, he conceived the idea of a hollow horn which carried at its point a "looper whirl" and had within its body the necessary mechanism for driving this whirl. The first patent for this machine was taken out by Mr. Blake on July 6th, 1858.

The horn was stationary so that, after sewing down one side of the sole, the shoe had to be taken off and started down the other side. The machine would not stitch across the toe and this part of the work had to be finished in some other way, such as pegging or nailing.

About the same time a crude machine was devised for putting the uppers and soles together by metallic fastening. Strips of wire about ten feet long were fed into the machine which cut a thread on the wire and forced it through the sole. The wire was cut off at the surface of the sole, but points were left sticking up that had to be rasped or finished off by hand. The machine worked by hand and could finish only twenty-five to thirty pairs per day.

The First Boot-Riveting Machine

There is, incidentally, a strong local tradition that the first boot-riveting machine to be used in this country was invented by Derham Bros. of this city in the 1860's. Direct evidence of this is lacking, but it seems highly probable that the claim is an authentic one.

During the same period there had been invented at Street a machine for the building and attaching of heels. The heels were built up in solid iron moulds and put under heavy pressure with a screw press. Then holes were pricked by a machine, rivets placed in them, and so they were attached to the boots. This was the first machinery used in England for this sort of work. It was not patented, but was worked in great privacy and for a long time kept a complete secret.[2]

By 1875, there had been perfected in the United States a machine which was a great improvement on the previous metallic attachment method, in that it took wire on which a screw thread had previously been cut, and turned or screwed it into the leather, no awl or piercing instrument being used. The length of the screw was automatically determined and, as a heavy pressure was brought to bear on the sole, the outsole, upper and insole were held firmly together while the screw was turned into place. The threaded screw prevented the fastening from working loose or from forcing up the insole. Where firmness and solidity were desired, the machine seemed to meet all the requirements. This is, in fact, precisely the principle by which today the bottoms of heavy working boots are attached, though the speed and operation of the machine have been much improved.

There followed lasting machines which turned the uppers over the last and attached them by metal tacks to the insole. Finishing machines were introduced which trimmed the edge of the bottom of the boot by means of a revolving knife, and others by which the trimmed edge was set and ironed.

"Giving Work Out"

There are two general comments which I might perhaps make at this point. Although much of the process of boot making was still being done by hand, the introduction of machinery for certain basic operations marked the beginning of the sub-division of labour, and it thus facilitated the factory system of manufacture. Nevertheless the old practice of "giving work out" died hard. For many years after the cutting and stitching of the uppers in the factory had become the accepted method, the assembling of the uppers and bottoms and much of the finishing process were done in the homes of the bootmakers. They collected the components from the factories and took the completed boots back to them for inspection and disposal. Many of the dwelling-houses in Kingswood, for instance, had their workshops in the yard at the back—built apparently at the same time as the house itself. As late as the years before the First World War, anyone walking through the Kingswood streets at a late hour on a winter's night would pass many a lighted workshop at the back of the houses where the bootmakers, with some lost time to catch up perhaps, were finishing off the work which had to be "shopped" next day. The clink of the file striking the rivets or hob-nails and the thump of the hammer upon the leather are sounds well remembered by the older generations,[3] and indeed they still recall to me memories of my boyhood days.

Need for Skilled Workers

My other comment is that even when most of the operations that could be usefully mechanised, had been, the workmen still positioned and held the shoe. Stitchers, nailers, lasters were improved so that they could do more intricate work, do it faster, and do it more uniformly; machines were developed that drove many nails at once, a thing that not even a dozen shoe-makers could do. But the man still *worked* the machine and did not merely *feed* it. He still had to exercise, throughout the job, his guiding and manipulative skill.

I have mentioned some of the most significant inventions in the development of shoe machinery, but it has necessarily been a very sketchy and incomplete account. Today all the principal operations that go into the making of a pair of shoes are done by machine. Those operations amount to anything between 150 and 200 depending on the type of shoe, and not far short of that number of different machines are used in a modern factory at the present time. And yet I suppose that to an engineer the best organised shoe factory may appear as something of a shambles. I think he might find the process of moving the work to the different machines a subject of technical interest and importance, but I suspect that he would take some convincing that the whole thing could not be tidied up, simplified and standardised.

I am not so sure that he would be right—given that shoes have to be made on lasts, and made out of leather. The whole problem turns on these two factors and upon the very nature of the automatic machine. The last itself is a thing of a highly unmathematical shape. Not only so but, partly because of the infinite variations in the dimensions of the human foot and partly because of the dictates of fashion, there must exist an immense number of different lasts varying in toe shape, pitch, proportion and so forth. It is not just that there is a profusion of different last models but that the multiplicity of pieces, of fractionally varying size, that comprise a complete set of upper patterns for each model run into many hundreds. In a man's plain Oxford shoe there are the vamp, the cap, and two quarters (each of these a different shape for the left and right foot), the tongue, the back-strap and three separate pieces for the lining. The standard variation in a last (which of course necessitates a corresponding variation in the sections of the upper pattern) is ⅓" in length and ¼" in girth for each full size, and, particularly in the case of women's shoes, these variations involve slight adjustments to other components, such as the height of the heel. It is common in America for one last to be used in six different fittings (or widths as they call them there) and each width has 15 or more different lengths in men's shoes size 5 to size 13, including half-sizes. If you've been multiplying all this in your heads, your total number of "bits" must already be approaching four figures—and we've only been considering one "model" of a last.

Variation in Materials

Finally, the making of shoes consists, in principle, in covering these infinitely varied lasts with a material which itself is little less variable. Just as human feet are dissimilar, so are the animals from whose skins leather is derived. Not only are no two skins or sides of leather identical in shape and texture, but within the area of a single skin or side there is a great variation of thickness and fibre and in the amount of its stretch. What makes for an even greater complication is that changes occur in the pieces of leather cut from the skins during the various processes of turning them into a pair of shoes. Two soles, for example, which are cut to exactly the same shape, which are—or have been made—identical in substance, and which appear to be similar in texture, will behave differently when wetted or tempered in the course of manufacture. They may also behave differently when subjected to the pressure of the moulding or levelling machine which compresses and consolidates the upper and the bottom of the shoe. Even the area can be appreciably altered in this way. I have heard of the Rockwell test, which I believe is applied to steel to determine its hardness, but I do not think any such device could be practically used for such a raw material as leather.

Perhaps I should mention here that the chief purveyors of machinery to the shoe trade (apart from upper-stitching machinery) are the British United Shoe Machinery Company, who are controlled by the United Shoe Machinery Co. of America. I am indebted to them for much of the factual substance of this talk. They manufacture some 350 different types of machine for which they provide a maintenance service from depots in the chief shoe-making centres of the country—and, indeed, of the world. In this country and the U.S.A. they employ upwards of 1,000 research workers, and though all shoe manufacturers are not on cordial terms with them all the time, I think it only fair to say that they are a highly efficient and progressive organisation. They do not suffer from the virulent competition that we poor shoe manufacturers do, but there is nothing of the slothful indolence about this great Company that is commonly attributed to monopolies—or near-monopolies. It is interesting that at their headquarters in Leicester they maintain a stock of more than 100,000 separate and distinct machine parts, and that their total stock of parts for servicing is maintained at a figure of about 9½ million!

Difficulty of Automation

The difficulty of using fully automatic machines, in conjunction with a queer-shaped thing like a last with all its variations of measurement, and an inconsistent and capricious and unpredictable material like leather, is obvious, for it lies in the very nature of an automatic machine. Such a machine must do the same intricate thing over and over again—the very same thing precisely and exactly. Such machines will add and multiply and divide pounds and shillings and feet and inches, but only because two and two always make four. In shoe-making you never know when they are going to make three and fifteenth-sixteenths! It is, of course, this degree of imprecision and these apparently inevitable variables that have determined the shape of the manufacturing process and the nature of the machinery employed. The machines are complex and intricate, but for the most part they remain elaborate power-driven tools. Since it cannot be foreseen in advance exactly what is going to be fed into the machine, it has to be so built that it can adjust itself according to the measurements which it takes from the individual shoe as it is fed into it. As we have seen, the method of manufacture is to take various components which have been manufactured, or cut, to close tolerances, and then assemble or fit them together like a jig-saw. The process is sequential, adding and altering process by process, and as it continues there develops an accumulation of small errors, corrections, and compensations.

The social and economic aspects of all this are interesting. The decline in craftsmanship, and in the sense of personal satisfaction and personal responsibility that the craftsman experiences, has had profound social implications which it is perhaps outside the purpose of this talk to examine. The skilled operative in a shoe factory works hard and his job demands mental concentration and adroit manipulation, but I am inclined to think he gets more kick out of his work than does the bored, unskilled machine-minder employed in many other industries.

Incidentally, his sense that he is making a real contribution to the final result is increased by the fact that in the shoe industry factory-units are generally small. According to a report published of a visit to the States in 1945 by two prominent members of the industry in this country, the average of productive employees per establishment was 182 in America, compared with 152 in the United Kingdom. These figures, however, are given subject to certain qualifications, though they are not likely to be seriously inaccurate.[4] Owners and directors are usually practical men who concern themselves closely with the day-to-day work of the factory: they are by no means a remote and Olympian body who have little personal contact with the workers in the shop. All these things, in my opinion, have contributed largely to the remarkable harmony and mutual confidence between owners, managers and men in my industry; we have had no major strike for nearly sixty years, and few agitators or political extremists are to be found among the 80,000 men and women that the industry employs. Incidentally that last strike—in the year 1895—was a very high-spirited affair. I have newspaper cuttings from the *Western Daily Press and Mirror* of that year, running into scores of columns and giving verbatim accounts of the speeches and statements of the protagonists. It is hard to pick out, from all the verbiage, exactly what the trouble was about, but undoubtedly the increasing use of machinery was a big factor. My father was a mild mannered and conciliatory man—at any rate by the standards of those days—but he was that year Chairman of the Kingswood Manufacturers' Association, and as such he had the doubtful pleasure of hearing a brass band, recruited I suppose from the ranks of the strikers, play Handel's "Dead March" from "Saul" outside his office window.

But from that time reason and good sense have prevailed, and at least half of the credit for the satisfactory state of affairs today is due to the wise, responsible, and progressive men who have occupied, and still occupy, the higher positions in the Shoe Operatives' Union.

I have made something of a digression, but it brings me back to a question which is implicit in my account of the development of shoe-making machinery. If, in the future, stress of competition eliminates the smaller and weaker firms, and if those that remain tend to fuse together into larger companies and bigger units, then the development of fully automatic machines may be facilitated and speeded up. Moreover, if leather gives place more and more to synthetic materials—plastics for uppers and linings and resin-rubber compounds for soles—then the whole pattern of the mechanical development of the industry may indeed undergo a transformation. A smaller variety of lasts, styles and types per factory unit, more uniform raw materials and perhaps a greater precision in the preparation of parts and components may provide an economic justification for the heavy initial cost and the great technical complexity of developing fully automatic machinery. We may one day use machines which will take the shoe, position it for the operation, work upon it and eject it—being merely fed, and not skilfully manipulated by the workman.

Whether the shoe industry is destined to develop along these lines I cannot tell. It may be that a rising standard of life will bring with it an increasing expenditure on clothing and footwear, and if so fashion changes may be more frequent and styles may be turned out in an even greater variety and profusion. Certainly that has been the trend in recent years. You have only to look at men's feet today and compare the casuals, sandals, sports shoes with lattice fronts, rings instead of eyelets, all in a great diversity of shapes and colours and designs—you have only to compare such extravaganzas with the plain black and brown Oxfords that used to be worn by 90% of men before the War, to perceive the change that has occurred.

I don't know much about women's shoes, or, if it comes to that, about women, but their shoes appear to me to show as much diversity as their faces and figures. These trends certainly do not add to the likelihood of ultimate production by the completely automatic machine.

Keeping the Interest in the Job

Nor, as I have said, do I feel satisfied that automatic production would make our industry more attractive to young entrants. Taking the horse-work out of the industry, as the Americans call it, is all to the good, but if you take the interest out of it too, and the sense that you, at least as much as the machine, are contributing to the making of an aesthetically satisfying article, then you may prove in the long run to have made industry less and not more attractive. I was struck by a remark in a recent B.B.C. talk in the series, "Prospect of Britain". "We seem to be relying at present, in the face of extreme economic need, on stimulating production among wage-earners by systems of piece-rates and bonus incentives. But we must not think that these by themselves will be enough. The most important change we can introduce will be to make the work of the industrial wage-earner socially satisfying. We can do this by learning to think of the machine as a cultural agent and by developing the social opportunities and obligations of factory life. No society can long continue in health by merely paying for work which it cannot make satisfying".[6]

However, this is a highly controversial subject, and some of you may be anxious to challenge the proposition that the development of fully automatic machinery is socially retrogressive. Whether it is so or not, the United Machinery Company of America are devoting much research in that direction. Their Research Division in Boston, I hear, are now demonstrating what they describe by the unlovely phrase "an operatorless link". This is a set of six machines electronically controlled, when the shoes progress along the link, and are automatically fed into each machine as the appropriate station is reached.

(Continued on page 35)

COLOUR PRINTING PROCESS AND PRODUCTION IN A PRINTING INDUSTRY

by H. J. JARROLD.

Educated at King Edward VI School, Norwich, and Queen's College, Cambridge, Mr. Jarrold later studied printing and bookbinding in Leipzig. He is Chairman of Jarrold and Sons, Limited, Printers, of Norwich, Vice-Chairman of the Technical Committee of the British Federation of Master Printers, and a past Chairman of the Research Committee of the Printing, Packaging and Allied Trades Research Association.

Mr. Jarrold

Colour printing is today more than ever in evidence, particularly in mass-produced magazines. Almost all of this is in four colours: yellow, magenta, cyan blue and black. There are still scientific and technical problems to be solved, but as the present progress towards their solution continues the use of colour will eventually become practicable and economically possible for a much wider range of printed illustration.

Black-and-white illustration from blocks dates from the invention of printing. Photographic methods of block production have been in wide use for over sixty years. As a black-and-white illustration is in effect only an impression of a coloured picture, a wide variation in tone is acceptable to the user of print, even in high quality work. For colour printing, on the other hand, even of the cheapest mass-produced kind, the result is so near to the original that criticism of slight colour variation may arise and it is, in fact, still almost impossible to obtain, even in high quality printing, the accuracy and regularity of colour that a critical eye might reasonably demand.

There are three important printing processes in use:

1. Letterpress, with a raised printing surface, the oldest and most widely used method.

2. Lithography, with the printing surface and non-printing surface at approximately the same level, but the printing surface chemically prepared to retain a greasy printing ink and the non-printing surface to retain a thin layer of water to repel the greasy ink. In spite of the apparent complication this process is easy to prepare and is the fastest growing process. It is used for most labels, almost all posters and perhaps 10% of all other printing except magazines, for which it is little used at present.

Lithography is almost always printed today not direct to paper, but *via* an intermediate rubber-covered cylinder. There are practical advantages in this; the rubber adjusts itself to the roughness of the printing plate and makes the process less dependent on the smooth papers which are preferable for other processes. It reduces chemical action between the water wet plate and such chemicals as may be present in the paper. As the image is transferred, or 'offset' from printing surfaces to rubber cylinder and from rubber to paper, the process is now often known as the offset process.

Collotype is a rather delicate (and today obsolescent) variety of lithography.

3. Gravure (or photogravure) has a sunk printing surface which forms a mould for the ink. It is rather costly to prepare, but gives high quality, even on cheap paper. A liquid and volatile ink is used for this process. It is used on a small scale for high quality art reproduction and on a rapidly increasing scale for cheap illustrated magazines. For high quality colour work it has the disadvantage of fairly high cost, but more seriously of being rather difficult to control.

A fourth method is still in the experimental stage, but may become of importance in the future. This makes use of an electrified surface to which charged powders are attracted. It appears to offer possibilities of very high speed and cheapness, but its application to colour printing appears to be far in the future. The American copying process of zerography, in which a selenium-coated plate is electrified and the charge on it destroyed by the action of light in a photographic manner, is of remarkable simplicity and speed and is one of the forerunners of such electrostatic printing.

What is Colour?

What is colour? Even this is not easy to describe accurately and is not wholly explained scientifically. For at least 150 years it has been known that our vision in a good light seems to be based on three kinds of sensitive receptors: blue, green and red. When we look at a spectrum we see first red with our red sensitive receptors, then yellow with our red and green both acting, green with our green receptor and also red or blue receptors, according to which part of the green we are looking at, and so to blue. Finally the extreme end of the spectrum appears slightly purple, because not only the blue, but to a small extent, the red receptor is activated by it. Colour-blind people are those who have only two or, in rare cases, one kind of sensitive receptor. Although the facts seem to fit this theory well, the presence of three kinds of receptor has not been anatomically demonstrated. There are two kinds of receptor, but one of these, called "cones", operate only in a fairly strong light; the other, "rods", operate in a dim light; of course, with a dim light we are all colour-blind, so it might be supposed that there are three kinds of cone. The mechanism is not yet discovered.

A further complication arises from the fact that our perception of colour is not constant. Not only do we adjust our eyes to intensity of light (by closing down the "diaphragm"—the pupil) but we adjust to a surprising degree to variations in the colour of light. Although we notice that some colours look different in most artificial lights as opposed to daylight, we do not notice the enormous change that any simple instrument can show. If we see a blue on a white ground it looks darker than if we see it on a black ground, and if we see it on a yellow ground it seems much more intense. And yet, if we see two colours side by side which vary so little that they can hardly be detected as different by scientific means, we can clearly see that they are different. The result of this is that, although we have a quite precise method of describing the musical notes of the ordinary piano, we have only the vaguest way of describing the 3,000 or so distinct colours that can be separated. In fact, for most people their colour language would not describe more than about twenty different colours and perhaps twice as many more by the use of the words "pale" or "dark". Two different methods of describing colours have been used; one is the scientific method, which states the amount of blue, green and red light absorbed. This is an international method, but still requires accurate and rather tedious measurement and, in fact, does not give the information the user needs. If, for example, we have a certain green and a paler version of the same colour, the trichromatic measurement would not tell us that there was any resemblance between them. An alternative method, which although less scientific is more useful, takes a number of rather arbitrary bright colours, covering not only the complete spectrum, but that range of colour between violet and red which includes the various shades of purple between these two colours. All other colours may be described by numbering these basic or "pure" colours and counting the amount of white pigment or black pigment which has to be added to the "pure" colour. Ostwald in Germany and Munsell in America prepared colour atlases on these bases and each has considerable use today. Difficulties of these methods lie in the necessarily arbitrary choice of the "pure" colours. For most hues existing pigments and dyes are not as bright as is desirable. Fugitive colours are obviously unsuitable. It is difficult to prepare large numbers of samples with the accuracy and permanency that is desirable, and simple methods of measuring accurately enough without the use of samples have not been devised.

Colour specification is, therefore, still in a very unsatisfactory state, so that the printer, like any other user of colour, starts with a poor foundation. If he is merely printing coloured lettering or colour patches he will do his best to match a sample given him, but he must be careful. The colour of the ink he uses will look different when dry to when it is printed. If it is to be exposed to sunlight he must chose light-fast inks—this may mean he has to avoid some of the more brilliant pigments. If used for such a purpose as soap packing, it must be alkali resistant —some common pigments lose their colour even if exposed to weak alkali. For other purposes it must be acid-resistant; if it is to be varnished, it must not dissolve in the spirit used as a varnish solvent.

Printing Inks

Printing inks are in essence high quality paints—rather more finely ground and more concentrated. Ordinary printing inks dry by oxidisation by the air, some of the newer inks by polymerisation. Newspaper inks, which are printed at high speed, dry by absorption of the vehicle into the paper, gravure inks by evaporation. Inks must be adjusted to suit the paper—some papers absorb so much ink vehicle that the pigment is left on the surface as a powder which rubs off. This can, of course, be avoided by suitable treatment of the ink, but acid in the paper, or high humidity in the atmosphere, to name only

two causes, can delay drying for some days of ink which, for high quality work, would be expected to dry in about twenty-four hours. The one exception is gravure ink, where drying is by evaporation and occurs in a matter of seconds.

Colour Reproduction

I have mentioned the problem of the eye as an instrument for seeing colour. In reproducing colour illustrations or colour photographs we normally photograph in three colours plus black. The colours are, of course, the subtractive ones (removing one-third of the spectrum at a time), yellow, magenta and cyan blue. Pictures made by the projection of separate coloured light use the so-called additive colours, green, red and blue, to which the eye is sensitive. The Dufay process of photography, using coloured areas side by side, uses this method. White is obtained by red, green and blue patches side by side, yellow by red and green, green or red by green or red only. It is clear that the pictures will be very dark and in the alternative subtractive process, instead of adding colour side by side, the minimum light is subtracted to give the desired colours. Yellow subtracts blue, giving an impression of yellow; magenta subtracts green; cyan blue subtracts red. For white nothing has to be subtracted. For black, unless black ink is used, all three colours must be superimposed, each subtracting one-third of the spectrum, the three together subtracting the whole spectrum. Yellow and magenta superimposed remove the green and blue of the spectrum, leaving only red; yellow and cyan remove blue and red, leaving only green. As the best cyan ink is rather dull, some of the green is removed also, giving a rather dark, dull green. The black, although theoretically unnecessary, has great practical advantages. Type is much pleasanter in black than in red or cyan blue and, of course, yellow would be unreadable. Shadows will be formed by the superimposition of all three colours, but owing to variation of one colour or another are difficult to maintain sufficiently neutral or dense without the help of the black. Black ink is cheaper and dries more quickly than three superimposed colours, so that for a number of reasons the black working makes the work easier and gives better quality at little extra cost.

Introduction of Multi-colour Machines

Until recent years, colour was printed almost entirely on one- or two-colour machines running at slow speeds. A one-colour machine meant the work had to go through the machine four times even to print one side of the paper and on a two-colour machine twice. Until about 1928, such printing was carried out on hand-fed machines with effective speeds of 1,000 per hour or less. Automatic sheet feeders raised this to 2,000 or even 3,000 an hour. As paper readily stretches with slight changes in humidity and successive printings must register accurately, practical printing sizes for colour work were limited to about 36 x 46 inches, or even smaller. Such slow speeds, one or two colours at a time, in such small size sheets were, of course, not only too costly, but would take an impossibly long time on large edition magazines or other very large quantity work.

A number of developments took place. The most important was the use of multi-colour machines, printing all four colours in one operation. Theoretically all that was necessary was to put four single-colour machines together with some mechanical device for transferring sheets from one to another. Before this could conveniently take place, rotary machines were necessary. The conventional machine still used for most commercial letterpress printing consisted of a flat printing surface, weighing several hundredweight, reciprocating under a revolving cylinder which carried the sheets of paper. By placing the printing surface on a cylinder, reciprocating motion is eliminated, the mechanism is simplified and higher speeds are possible. For letterpress the making of the necessary curved plates retaining colour register, although curved, presents difficulties and high costs which have still only partly been overcome. The other processes have easily been adapted to rotary methods.

The printing of four colours in one operation not only speeds up operations, but eliminates the possibility of variation in the paper between printings with the misregister that this causes. It is thus possible to use much larger sheets—about twice as large, 50 x 70 inches being usual. Speeds of all kinds of machines have been increased greatly by improvements in design, and elimination of waste motion at every point, so that now 4,000 and even 6,000 or more per hour are possible in this larger size. There are still only a few four-colour machines in use in this country, although no doubt there will be many more soon.

Special Purpose Machines

For the production of the magazine with a circulation of a million or more, such as some well-known weeklies and monthlies, much higher speeds, even 15,000 or 20,000 per hour, have been obtained by special purpose machines printing from the reel of paper in four colours both sides of the paper. Such machinery costs hundreds of thousands of pounds and is only suited to the size of the magazine for which it has been designed. The sheet-fed machine, although capable of less than half the speed, is much more flexible for a varied class of work. It can be started more easily and generally gives higher quality work. Printing from a reel on a multicolour machine presents problems of register, although these have been partly solved by electronic devices.

One of the big problems of colour printing today is the high cost of paper and the research still necessary to produce paper which will have the mechanical properties enabling it to give good printing quality at high speeds. Printing often has to be carried out at slower speeds than the machine can accommodate, because the surface of the paper will not stand rapid printing with the mechanical pull of the printing ink on the fibres.

The use of colour photography, although it dates from as far back as 1865 (and even earlier) was not really on a firm foundation until the introduction of Kodachrome film in America in 1935 and of Agfacolor in Germany in 1936. These set far more exacting problems than the reproduction of artists' drawings which had been the normal subject until that date. The straight photography of any subject through filters and the direct preparation of printing plates required heavy manual correction to obtain good printing results, owing mainly to deficiencies in the best magenta and cyan blue inks yet possible. On photographic subjects manual correction is not only tedious, but usually destroys photographic quality. Research, principally by Eastman Kodak in America, has been directed to making such corrections as are necessary by photographic or electronic means. The latter appears to offer considerable advantages and at least two kinds of machine are under development in America by the Radio Corporation of America and Time-Life organisation respectively. These machines are, however, still far from perfect and the alternative means of correction by photographic methods is not impractical, although it entails the making of many more than four photographic plates.

Automatic Controls

If correction is to be minimised, much greater precision must be exercised in all photographic operations than is normal. This means automatic controls at stages of exposure and development. Additional plates must be made to correct faulty tone rendering in light parts, a characteristic of most photographic processes, especially the transparency processes. Further plates must correct for defects in the blue and magenta inks respectively. Means must be found for preparing a black plate of the required strength in the shadows, but not in the brighter colour where it will come unless eliminated. There are other problems and these range from controlling the exact tone in each colour through photography, the making of printing plates and the printing itself with its very thin film of printing ink. Any variations in one colour without corresponding variation in the other colours—and variation in one colour is obviously much more likely—will cause changes of hue which may easily be offensive. This particularly applies to light colours such as flesh tones and in dense shadows. In fact, the problem of colour printers is mainly a matter of maintaining tone values in the light tones and in the shadows. Even if the colour otherwise appears good, loss of flesh tone obviously spoils pictures with faces in them and loss of tone in the shadows will cause a picture to be flat and lifeless.

In letterpress and lithography tones are obtained by splitting the image up into fine dots—the finer the dots, the lighter the tone, and *vice versa*. Although the same method may be used in gravure, this process has the ability to vary the thickness of its ink film—you will remember it is a kind of mould—so that it more normally obtains its tones by the varied depth of its etching and, therefore, of the ink which fills it in printing.

You may expect to see a vast improvement in the quality of colour printing and to see it spread to a much wider use. We live in a coloured world. Black-and-white is a poor substitute. Mass production is gradually reducing the costs of colour and research will make possible much more consistent high quality.

" DEVELOPMENT OF MACHINE PRODUCTION IN THE SHOE INDUSTRY " *(concluded from page 31)*

My talk has not clearly described the various traditional methods of making footwear—riveting, sewing, welting, etc.—nor has it referred to the new methods (of which at least two are radical departures from the traditional) that have been developed—or are being developed—since the War. It has alternated between the historical, the speculative and the sociological—with, I am afraid, much less of the profoundly technical than you are accustomed to. For that you must blame your Secretary and his advisors. But I have enjoyed putting these facts and thoughts down on paper, and if you have been tolerably interested, I am sufficiently repaid.

References

1. " Clarks of Street ", page 13.
2. " Clarks of Street ", page 13.
3. " Cobblers Tale ".
4. Report by Denton & Colvin, Spring, 1954.
5. Talk by Christopher Salmon.

" TIME, SPACE AND PRODUCTIVITY " *(concluded from page 38)*

An endeavour has been made in this paper to emphasise the fact that even small reductions in the Direct Labour content of the manufacturing cost of a product, made by efficient methods, result in a chain reaction of other advantages. Its main purpose has been to show that whenever consideration is being given to the improvement of Productivity, there must be taken into account not only the ever important influence of Time but also the far-reaching consequences of Space.

TIME, SPACE AND PRODUCTIVITY

by A. B. WARING.

Managing Director, Joseph Lucas, Limited.

Presented to a Joint Meeting of the Institution and the Birmingham Productivity Association, at Birmingham, 15th September, 1954.

TIME is the basis of all industrial activity. The size of the factory, the type and number of machines, the tools and equipment are dependent on calculations based on Time. The greater the appreciation of the Time factor, the higher will be the standards of productivity.

Wage incentives are based on Time and increasingly take the logical form of Time allowances, although the majority of incentives are still expressed as piece prices or job allowances which have been worked out from Time observations.

Highly developed technical ability for its full achievement must be matched by equally highly developed ability for the determination and application of the Time factor.

The continued improvement in the standard of living implies that the subsistence level has been passed and that consumer goods, of ever increasing volume and variety, at prices universally acceptable, become available.

The greater the volume of production the more highly developed become the methods of production and operations become more and more automatic so that where at one time minutes were used for their calculation, seconds and fractions of seconds take their place, and where hours were taken to produce the final products, they are now produced in minutes. It is at this stage that the danger arises of presuming that when the Direct Labour Cost of an article has been consistently reduced—maybe from hours to minutes—there is little advantage to be gained by further improvement in the methods of production when such further improvement will result in only a few pence being cut from the cost of direct labour. That this is a fallacious line of thought will be demonstrated.

ORIGINAL PRODUCT COST

STAGE I

Product "A"

Output 100,000 articles per annum

	Total Cost £	*Cost per Article* £	s.	d.
Materials . . .	100,000	1	0	0
Direct Labour . . .	37,500		7	6
Indirect Labour and other Overheads @ 200% .	75,000		15	0
TOTAL FACTORY COST	212,500	2	2	6

PRODUCT COST AFTER MAJOR REORGANISATION

STAGE II

Product "A"

The product has been redesigned and re-laid out and, as a result of reduced cost and selling prices, the annual output basis is estimated at 250,000 articles per annum.

	Total Cost £	*Cost per Article* £	s.	d.
Materials (substitute materials and design economies) . . .	187,500		15	0
Direct Labour (reduced operation cycle times) .	34,375		2	9
Indirect Labour and other Overheads @ 350% .	120,313		9	7
TOTAL FACTORY COST	342,188	1	7	4

= Reduction of 15/2d. or 35% in total cost per article.

The points to be noted are:—

1. The job has been laid out on the assumption that with a substantial decrease in cost the demand will be more than doubled.

2. The cost of production has been reduced by 35% by the complete redesign of the product, having in view—

   (*a*) economies in materials by substitution of cheaper materials and in the weight of materials used;

   (*b*) design for production enabling a complete re-layout, involving new automatic and specially developed plant and equipment, resulting in the production time being reduced to little more than one-third of the original time.

   (*c*) an increase in the *rate* of overheads, but a decrease in the overhead cost per article.

Although the example might be cited as extreme, it is what can, and does, take place when a product lends itself to simplification of design and more automatic production processes. It might take a year to be made effective but the consequences would be the same if the change took place by stages over a period of several years. It involves a major operation on the part of designers, process and methods engineers and the manufacturing organisation.

Outstanding results having been achieved, it might well be considered that further economies would not be worth while. Particularly would this appear to be the case because the Direct Labour Cost per article has been reduced already by nearly two-thirds, from 7/6d. to 2/9d. The changeover has resulted in shillings being knocked off the Direct Labour Cost per article and it would appear to be impossible for any more shillings to be so deducted. Further improvements in production methods can result in reductions of pence only and we can now consider whether such further production economies are worth while.

Let it be supposed that the methods engineers have worked out means for still further economies, which would result in a reduction in the Direct Labour Cost from 2/9d. to 2/6d., and that the capital cost of the plant and equipment necessary to make the saving would be £15,500. Let us ask ourselves the question —is the change worth while?

A saving of three pence per article on the Direct Labour Cost calculated on the existing production basis of 250,000 articles a year, would result in an annual saving of £3,125 so that it would take five years to recover the investment of £15,500 in the plant and equipment. If this were the whole picture, it would be a matter of argument whether or not the disturbance which always results from factory changes is worth the potential saving; in point of fact it is far from being the whole picture, as the next example will demonstrate.

PRODUCT COST
AFTER FURTHER REVISION

STAGE III

Product "A"

Based on methods improvements resulting in a minor decrease of 3d. in Direct Labour costs per article and an expansion in output as a result of increased capacity to 275,000 articles per annum.

	Total Cost	*Cost per Article*		
	£	£	s.	d.
Materials	206,250		15	0
Direct Labour	34,375		2	6
Indirect Labour and other Overheads @ 375%	128,906		9	4
TOTAL FACTORY COST	369,531	1	6	10

= *A further reduction of* 6d. *or nearly* 2% *in total cost.*

The points to be noted are:

1. That a decrease of 3d. in Direct Labour Cost results in a higher rate of overheads when expressed in terms of a percentage on Direct Labour but which nevertheless when expressed in money terms per article produced shows a reduction of 3d.
2. The total cost reduction shown is 6d. or nearly 2% per article.
3. The annual output capacity has been increased from 250,000 to 275,000 articles per annum.

The conclusions to be drawn from the example are that the changeover is very well worth while, not only because of the 3d. saving in Direct Labour Cost but also because of other consequential advantages:—

The saving of 3d. in Direct Labour is the equivalent of a 10% reduction in production Time.

A 10% reduction in production Time has the same effect as providing 10% more productive Space.

A 10% increase in Space makes possible an increase in productive capacity with some reduction in overheads per article and, as a result, a wider market.

More important than any other factor is the fact that a saving of 3d., or 10%, in Direct Labour if pursued and encouraged, will eventually lead to further economies in Time and Space with resulting decreased costs, increased capacity and sales; but if not pursued or discouraged, will lead to stagnation.

High productivity results primarily from a state of mind which takes into account not only immediate cost advantages but also the indirect but far-reaching advantages to be gained by economies both in Time and Space.

Space may be defined as the area taken up by the factory or by the plant, equipment or services within it. High utilisation of Space implies that the plant, equipment and services within the factory are used to the very best advantage.

Of the various factors adversely influencing the high utilisation of Space, single-shift working is the most obvious.

Any discussion on the subject of shift working arouses immediate reactions to its sociological consequences, such as its affect on family life in the case of the married man who works on a night shift and has to sleep whilst his children are playing about the house and take his meals at times different from those of the rest of the family. For other sociological reasons legislation prevents the employment of women and young persons on night shifts.

On the other hand, services to the community and to industry such as gas, electricity, transport, telephones, etc., have to be operated, of necessity, on a continuous shift system and many industrial processes concerned with steel, glass, chemicals, etc., can only be carried out on a continuous production basis.

Three-shift working is commonplace in American factories and taken for granted by management, staff and workpeople who are not conscious of any ill-effects, a fact commented on by many of the Anglo-American Productivity Teams. In British factories it is not uncommon for night shifts to operate, particularly in departments where very expensive machinery is in use.

Other things being equal, a factory working a single shift cannot compete with a factory making a similar product working two or three shifts, and this would apply if the single-shift factory was in England and the multi-shift factory was in Germany or elsewhere.

For a generation or more, it has been the tendency in British industry for the operation of multi-shift systems to be restricted and wages agreements with the Unions provide for penalities by way of higher hourly rates of earnings for shift workers. For the sociological reasons given and in the circumstances of today, when the great majority of the industrial population is fully employed on normal single day-shift working, it is unprofitable to contemplate the possibility of introducing three shifts where only one exists. In many localities, the building up of night shifts presents serious difficulties and it is not uncommon to hear criticisms of their efficiency; this is not because there is anything inherently wrong with them, but because of inadequate supervision.

A factory working a single day shift which is faced with the necessity of increasing production beyond the capacity of its plant and equipment, will in the ordinary course of events set up a night shift which will supplement the day shift but will not otherwise affect its normal working or the flexibility provided by its overtime hours. Where, however, the future prospects give promise of continued demands or in circumstances where it is not possible to set up a night shift or where an entirely new manufacturing unit is in contemplation, it is very well worth while to consider the economies and other advantages to be gained by the operation of a double day shift system. It should be mentioned that for a double day shift both men and women may be employed.

Taking the case of the engineering industry where normal working hours are 44 per week, if two day shifts are substituted, the hours worked would be 75 per week provided the first shift worked from 6 a.m. to 2 p.m. and the second shift worked from 2 p.m. to 10 p.m. With a five day week and a meal break of half-an-hour per shift, each shift would work 37½ hours per week. Operators would expect to earn the same on a two shift basis as would be earned on a single shift.

Basis of two-shift working

6 a.m. to 2 p.m. and 2 p.m. to 10 p.m.
with a half-hour break for meals.

Production hours per week = 75
Production hours increase
over normal week of 44 hours = 31 hours or 70%

PRODUCT COST ON TWO-SHIFT BASIS

STAGE IV

Product "A"

Assuming an output of 468,000 articles per annum, i.e. 70% more than single-shift working.

	Total Cost £	£	s.	d.	*Cost per Article* £	s.	d.
Materials . .		351,000				15	0
Direct Labour .	58,500		2	6			
Add 17½% increase in overall hourly rate, i.e. Shift Supplement	10,238			5			
		68,738				2	11
Indirect Labour and other Overheads @ 250% . .		171,845				7	4
TOTAL FACTORY COST		591,583			1	5	3

= *A still further reduction of* 1/7*d. or* 6% *on the previous cost of* £1 6*s.* 10*d.*

The points to note are:

1. As a result of shift working the Direct Labour Cost per article has increased by 5d. (17½%) but as a result of better utilisation of Space, the Overheads have been reduced by 2/- per article, making a net saving of 1/7d. or 6%.
2. As a result of the increased working hours the factory output has been increased by 70%, the greater volume being sold as a result of the reduced cost together with the profit margin being spread over the greatly expanded output.

The economy of Space gained by operating shifts results not only in a reduction in costs but in reduced capital investment. There is also an overall benefit that accrues by running plant and machinery for longer hours and, as a result, it is worn out and replaced with more modern plant at shorter intervals; in consequence, the factory is maintained in a highly competitive condition providing security for all employed in it.

(*concluded on page* 35)

The 1955 Associate Membership Examination

The 1955 Associate Membership Examination of the Institution will be held during the last two weeks in May. Entry Forms, which may be obtained from the Education Officer, must be submitted so as to be received at 10, Chesterfield Street, London, W.1., together with the appropriate Examination Fee,

(a) from candidates resident in the United Kingdom—on 1st April, 1955.

(b) from candidates resident outside the United Kingdom—on 1st March, 1955.

The examination timetable will be as follows:

Date		10 A.M.	2.30 P.M.
Wednesday	18th	Workshop Technology	Engineering Drawing
Thursday	19th	Practical Mathematics	Applied Mechanics
Friday	20th	English	Materials and Machines
Saturday	21st	Foundry Processes	Hot and Cold Forging
Monday	23rd	Machine Tools	Jig and Tool Design
Tuesday	24th	Metallurgy	Metrology
Wednesday	25th	Press and Sheet Metal Work	Applied Electricity
Thursday	26th	Welding Processes	Plastics
Friday	27th	Introduction to Industrial Management	Production Planning or Work Study

The Education and Membership Committees have recently considered the requirement that applicants for membership must pass in English in order to qualify in Part I. It was noticed that a considerable number of applicants qualify in technical subjects at Colleges—sometimes up to H.N.C. level—and then find themselves, perhaps quite late after having left school, having to pass in English.

The Committees stated they regard ability to use English as essential for a competent and practical production engineer, and affirmed that they will continue to require a pass in English before an applicant can be considered as qualified academically for either Graduate or Associate membership.

Lord Austin Prize

The attention of all Graduates of the Institution is drawn to the announcement relating to the Lord Austin Prize for 1954/55, which was published in the December issue of the Journal. The value of the Prize is £17. 10. 0. and the conditions of entry are as follows:

1. All graduates of the Institution under the age of 30 years may compete.

2. Essays may be submitted on any subject within the field of production engineering. Titles of essays and a brief synopsis must be sent to the Secretary of the Institution not later than 1st March, 1955.

3. Essays should be not less than 2,000 nor more than 4,000 words in length.

4. Completed essays must be submitted by 30th April, 1955.

Third Aircraft Production Conference

The Third Annual Conference on Aircraft Production, organised by the Southern Section of the Institution, is taking place at the University of Southampton (by kind permission of the Vice-Chancellor) on 14th and 15th January.

The theme of the Conference this year is "Integral Construction contrasted with Traditional Methods" and details of the programme have already been circulated.

It is hoped to public a full report of the Conference in the March issue of the Journal.

Mr. S. P. Woodley at Southampton

A most successful meeting took place in the Southern Section on 18th November last, when Mr. S. P. Woodley, M.B.E., Superintendent of Vickers Armstrongs (Supermarine) Ltd., spoke on "Provocative Tooling Methods for Aircraft". The Chairman of the Section, Mr. F. T. West, M.B.E., presided.

The photograph below, taken after the lecture, shows, left to right: Mr. J. W. Taylor (Section Hon. Secretary); Mr. A. W. Turner; Mr. T. Gilbertson (Section Committee Member); Mr. S. P. Woodley; Mr. F. T. West, M.B.E. (Section Chairman); Mr. W. Morgan, M.B.E. (Secretary, Machine Tool Trades Association); Mr. Norman Stubbs, M.B.E. (Editor, "Machinist"); and Mr. W. E. Goff (Editor, "Aircraft Production").

SOUTHAMPTON MEETING

"THE AUTOMATIC FACTORY —

What does it mean?"

National Conference to be held at Margate, 16th/19th June, 1955.

IN recent months considerable publicity has been given to the subject of the automatic factory. There can be few people in industry who are not aware of some of the steps taken in their factories which are part of the approach to what has been called the Second Industrial Revolution, so that automation is no longer a dream, but in many forms is with us today, and the future automatic factory, far ahead though it may be for most of us, is beginning to take shape in the minds of some people.

The dawn of this "automatage", as it was described by the President of the Institution, Sir Walter Puckey, at a recent conference on Electronics, is the subject of intense interest on the part of many people. The industrialist views it as one of the answers to his production problems. The scientist and technologist welcome it as the fruition of their skill and ingenuity. The economist looks to its contribution towards the maintenance of the country's trade and commerce and its prosperity. The sociologist and the educationalist are already trying to forsee and prepare for the effects on the human being of this latest and most interesting industrial development.

While much of the discussion about the effects of automation can only be based on conjecture at this stage, some inescapable facts emerge. It can be stated with some certainty that the development of automatic processes is of major assistance in improving the standard of living by increasing production per man, reducing costs and thereby extending markets. It can also be accepted that as time goes on exhausting manual labour will be reduced and the tedium removed from many operations and processes.

But the period of development of these processes throughout industry will be a long one and many difficulties remain to be overcome—some of which can be clearly seen at the present time, and others which no doubt will not be apparent until automation is more widely established.

It is desirable, therefore, that the advances up to date should be considered and as much information as possible gathered about the future picture. It is for this reason that the Institution of Production Engineers is to hold a National Conference at Margate, next June, on the subject of "The Automatic Factory—What does it Mean?" At this Conference it is hoped that managers, engineers, educationalists, scientists and sociologists will come together to examine what the future holds and to discuss their mutual experiences and problems. Particular consideration will be given to the impact of automation on the smaller firms.

This Conference will be the first held in Britain exclusively on this subject, which intimately concerns every production engineer. Already considerable interest in the Conference has been aroused by the preliminary announcements in the technical and lay press in the United Kingdom and abroad, and applications to attend are already being received.

Further details will appear in next month's Journal.

If you are contemplating attending the Conference you are advised to book your accommodation at Margate, as soon as possible. Lists of hotels may be obtained from the Secretary, 10 Chesterfield Street, London, W.1.

Western Section Dinner-Dance

This photograph shows members and guests of the Western Section assembled for dinner.

The Western Section of the Institution held their Annual Dinner and Dance at the Berkeley Cafe, Bristol, on Thursday, 14th October last. As is usual on this occasion, it was a civic function and the Lord Mayor, Alderman G. G. Adams, the Lady Mayoress, and the Sherriff of Bristol and his Lady honoured the Section by their presence.

The toast of "The City and County of Bristol" was proposed by Mr. R. S. Brown, Member, General Manager of the Aircraft Division of The Bristol Aeroplane Company. In his response, the Lord Mayor made reference to the engineering achievements in the City of Bristol.

The toast of "The Institution" was proposed by Professor A. R. Collar, Dean of the Faculty of Engineering of the University of Bristol, to which Mr. W. F. S. Woodford, Secretary of the Institution, responded.

The Chairman of the Western Section, Mr. E. F. Gilberthorpe, proposed the toast of "The Ladies", to which Mrs. F. G. C. Sandiford made a very suitable response.

Sheffield Section Dinner

The Annual Dinner of the Sheffield Section, held on 11th October, 1954, was obviously an enjoyable function. This photograph includes some of the prominent personalities who attended the Dinner. From left to right are Mr. D. A. Palmer, President of the Sheffield Chamber of Commerce; Mr. E. Levesley, Chairman of the Sheffield Section; Sir Walter Puckey, President of the Institution; Alderman J. H. Bingham, Lord Mayor of Sheffield; Mr. W. G. Ibberson, Master Cutler; and Sir Charles Goodeve, Director of the British Iron and Steel Research Association.

news of members

The President of the Institution, Sir Walter Puckey, has accepted the invitation of the Postmaster-General to serve on the Television Advisory Committee.

Mr. J. Winskill, Member, who is the Northern Area Sales Manager for the Newall Group of Companies, will now cover the Scottish area until a new sales representative is appointed.

Mr. F. Caldwell, Associate Member, has relinquished his position with Metropolitan-Vickers of Manchester, and has now taken up an appointment as Works Manager, Central Engineering Establishment, National Coal Board, Burton-on-Trent.

Mr. E. Percy Edwards, Member, has resigned his position as Joint Managing Director from the board of The Lapointe Machine Tool Company, Ltd., and has left the Company. Mr. C. T. Parkin has been appointed Managing Director as from 1st January, 1955. Mr. Edwards will remain at his office, White House, 111, New Street, Birmingham, 2, as heretofore.

Mr. George Crook, Associate Member, has been appointed Vice-Principal of Garrett's Green Technical College, Birmingham.

Mr. M. H. Horton, Associate Member, has taken up an appointment as a Lecturer at the Work Study School, College of Aeronautics, Cranfield.

Mr. A. H. Luker, Associate Member, has recently taken up an appointment with Messrs. R. F. Thompson Limited of Harlow, Essex, in their Die Design Department.

Mr. H. F. Maton, Associate Member, has relinquished his position as Chief Mechanical Engineer of Johnson, Matthey & Co. Ltd., and has now been appointed General Manager of their subsidiary company, The Harlow Metal Company, Harlow.

Mr. J. B. Montgomerie, Associate Member, has taken up an appointment as Works Manager with Glenfield & Kennedy (Aust.) Pty. Ltd., Adamstown, Newcastle, Australia.

Mr. G. Nichols, Associate Member, has now been appointed Acting Factory Manager of the Hatfield Factory of The de Havilland Aircraft Co. Ltd., on the closing of the Letchworth Factory where he was Manager until the end of September.

Mr. H. C. Perry, Associate Member, has resigned as Chief Production Engineer with Collars Limited, and has taken up an appointment as Production Engineer with the Plessey Company, Ilford.

Mr. G. A. Ricketts, Associate Member, has been appointed Overseas Sales Executive for Weeks Engineering Products Limited, Sunderland, in their Overseas Sales Division, London.

Mr. E. Ward, Associate Member, has been appointed Manager of the Production Division, Information and Research Department of the British Institute of Management.

Mr. Z. Funt, Associate Member, has been appointed Principal of the Technical High School, Belize, British Honduras.

Mr. B. Burkinshaw, Graduate, is now employed as a Senior Designer Draughtsman with General Descaling Co. Ltd., of Worksop, Notts.

Mr. A. D. Fogg, Graduate, has taken up the position of Assistant Works Manager, at A.E.C. Limited, Southall.

Mr. R. Gunnell, Graduate, has taken up an appointment with Skefko Ball Bearing Company, London.

Mr. T. P. Keenan, Graduate, has been appointed Chief Tool Designer with Lucas-Rotax Limited of Scarborough, Ontario.

Mr. John A. Lovell, Graduate, has relinquished his position as Planning Engineer with Jaguar Cars Limited, Coventry, and has now taken up an appointment as Technical Assistant to the Production Manager at The Iso-Speedic Company Limited, Coventry.

Mr. J. L. Noble, Graduate, has recently changed his appointment and is now a Process Layout Engineer in the Production Engineering Department of Hoover (Washing Machines) Limited, South Wales.

Mr. D. R. Portman, Graduate, has been transferred from the Rugby to the Liverpool Works of the English Electric Co. Ltd., to take up an appointment as Fabrication Superintendent in the Transformer Works.

Mr. R. J. Temple, Graduate, is now Engineer III, with the Ministry of Supply D.I.E.M.E., at Bromley, Kent.

Correction

An announcement in the December issue of the Journal inferred that Mr. Harold Vernon, Member, a Director of Thos. W. Ward, Ltd., of Sheffield, had been appointed Chairman and Managing Director of the Company. This was due to an editorial error which is greatly regretted. Mr. Vernon has, in fact, been appointed Chairman and Managing Director of Fredk. Town & Sons, Ltd., of Sheffield, whose entire share capital has been purchased by Thos. W. Ward, Ltd.

Hazleton Memorial Library

REVIEWS & ABSTRACTS

Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when ordering books.

Members are reminded that the Library service is available to all members of the Institution and the Librarian is always willing to assist with enquiries.

REVIEWS

"Graphical Spring Design" by V. Tatarinoff. *Brighton, Machinery Publishing Co., Ltd.*, 1953. 64 *pages, graphs.* 4/-. (Machinery's Yellow Back Series No. 32.)

This publication, like its companion volumes in the series, is essentially a guide-book for the specialist, and is intended by the Compilor "for the purpose of providing the designer with a number of useful starts and examples. . . . "

The text is in three chapters of approximately equal lengths:

I. Helical Springs.

II. Volute, Spiral, Cantilever and Disc Springs.

III. Beryllium Copper for Springs.

Chapter I opens with an explanation of the reasoning used in constructing the first chart, namely, the relationship plots between Load of Working and Diameter Ratio for Round Material Helically Wound. Use has been made of a correction factor to allow for inner coil fibre stress (American Research Committee on Springs 1928) and credit is due here, as throughout the publication, for the clear definition of units and symbols used in the developed equations.

Springs of sections other than round, i.e., square, flat, are treated, and on page 13 there is a curve of U.T.S. (Torsional) values for Silico-Manganese and .55%C. Steel Springs material related to Section dimensions that should lead to others being developed of the same form elsewhere in design offices, etc.

Plentiful examples throughout this section illustrate the points stressed; especially is this true of "Design for Minimum Overall Dimensions", which contains some excellent data on the determination of deflections when one helical spring is placed within the coil of a larger

Chapter II is quite thorough in its treatment of both volute formed and spiral formed springs and the slot article (pp. 52 to 54) on Bellville washer compression calculations is really excellent.

Chapter III on the beryllium copper alloy will prove of very considerable value to designers dealing with springs for highly corrosive conditions of working, irrespective of form that the springs must take.

K.J.A.

"The Writings of the Gilbreths" by Frank Bunker Gilbreth and Lilian Moller Gilbreth. Edited by W. R. Spriegel and C. E. Myers. *Homewood, Ill., Irwin*, 1953. 513 *pages*. £3. 0. 0.

This is a new testament on Management and Motion Study comprised of the early epistles and recorded lectures of F. W. and L. M. Gilbreth, the American pioneers of the science.

Most productive executives are now applying motion studied principles to their processes to a greater or lesser degree, but some may be surprised to learn that the Gilbreths had done it in great detail as far back as the latter years of the last century.

Mr. and Mrs. Gilbreth ran a building contracting organisation and, noticing the various customs of bricklayers of different nationalities, found that whilst each had advantages and disadvantages over the other, all used far too many movements of arms and legs in the laying of a brick. Intensive study of the craft resulted in specially constructed scaffolds, correctly placed brick piles and mortar boxes and properly designed tools, so that the eventual movements to lay a brick was reduced from eighteen to about five and previously unheard of quantities of bricks laid per hour by bricklayers who adopted the Gilbreths' method.

The first few chapters in this book deal with the study of motions in bricklaying and as there were, and still are, millions of bricks to be laid that trade provided an ideal field, but the knowledge gained and techniques developed soon spread to other repetitive processes with remarkable results.

Every contingency and need of a worker and his job received careful thought and attention in their investigations and, far from being a new form of slave driving, their methods resulted in that standard of high production at less effort for big wages under ideal conditions which is associated with American industry.

The psychology of management is also fully dealt with, the writings on fatigue study provide excellent reading and Gilbreths' motion study of work suitable for the handicapped and war disabled is most commendable.

The Editors have done a very good job in collecting together, eliminating the obsolete and publishing these writings of the Gilbreths and I commend the book to all managers, students of production, foremen, trade union executives and workers of welfare organisations. From personal observations of bricklaying methods still used in this country, even by large contractors, I would say that a study of the Gilbreths' work described in the early chapters and adoption of their methods by such contractors would pay handsome dividends.

S.H.

"Standard Costs for Manufacturing" by Stanley B. Henrici. 2nd edition. *London, McGraw-Hill Publishing Co., Ltd.*, 1953. 336 *pages, diagrams, charts.* £1. 19. 6d. (Mc-Graw-Hill Accounting Series.)

As its name implies, this is a book on standard costs in the field of manufacturing. It, therefore, deals only briefly with budgeting and hardly at all with financial accounting, but the treatment of standard

costing is full and detailed. The steps to be taken in changing over to a system of standard costs are clearly described, and there is discussion of the relative merits of systems, ranging all the way from semi-job costing to full standard costing. The emphasis throughout is on "responsibility accounting", with special attention being paid to those costs which are under the control of supervisory grades. To this end, there are two chapters dealing with incentive plans for supervisors. The terminology is American, but British readers will find little difficulty in that.

C.H.S.

"Fundamentals of the Working of Metals", by G. Sachs. *London, Pergamon Press*, 1954. 158 *pages. Diagrams.* £1. 10. 0.

When I was asked to review this book a special request was made that it should be done quickly. Now I have read it, the reason is obvious. The demand for borrowing the book should be very great among those people who wish to improve their knowledge of press work and forging.

There are 153 pages of well-planned information on most aspects of sheet metal forming. The book begins with the effects of temperature and speed of forming, chemical composition and grain structure. The second part is concerned with the tools used in actually shaping the material. The forming methods are classified and the reasons for many troubles explained. The book concludes by describing various forms of press tools, binding machines, rolls, etc.

Throughout the book a very practical outlook is evident. Economy is given as a reason for a certain type of tool, short set-up time is mentioned in another section. In some cases a complete sequence of operations is described. The book is amply illustrated, my only criticism being that a similar system is used for numbering the pictures as for the writing matter. This leads to confusion because the numbers do not correspond.

This work must not be mixed up with the usual type of "guide to press tool design and manufacture" book of which we see so much. This book must be read thoroughly and the fundamental knowledge thus gained must then be applied to the particular problem in hand. Because the information is so well explained, however, this task should not present much trouble.

I will conclude this short review by saying that "Fundamentals of the Working of Metals" is a first-class book, which is both useful and interesting to students, and invaluable to those people whose calling requires a sound basic knowledge of sheet metal forming and who do not wish to be "blinded by science".

R.E.M.

"Milling Cutters: a Guide to their Correct Selection, Application and Maintenance." Metal Cutting Tool Institute, N.Y. *Milling Cutter Division of the Institute*, 1953. 39 *pages Illustrations. Diagrams.* 10s.

This is a relatively short booklet, the fourth in a series devoted to milling as a machining process. It is more suitable for those who desire only the broad essentials of milling rather than for technical staff and management who require more exhaustive treatment. There is a tendency towards over-simplification and dangerous generalisations; for example, when discussing the relation of cutter cost and cutting speeds it is stated: "In general their life increases as the speed decreases".

The book deals with its subject in four sections, namely, Economics, Design, Application and Maintenance: by far the greatest part being devoted to the section on Design. This section, after commencing with classification of cutter types with photographs, proceeds to outline nomenclature, machinability of various materials, and then provides useful and detailed information and classification of the various types of high-speed steel and tungsten carbides. It should be noted that the data concerning high-speed steel and carbide is general information not necessarily applicable only to milling cutters, but also to other metal-removing operations.

A number of tables is published throughout the book giving usual data on speeds and feeds, cutter rake angles, horse-power required, etc., for the various basic work materials.

E.C.

"Deep Drawing": review of the practical aspects of Professor H. W. Swift's researches, by J. Willis. *London, Butterworth*, 1954. 134 *pages. Illustrations. Diagrams.* £1. 5. 0.

One point must be clearly understood before an attempt is made to read and digest the contents of this book; it is not a record of original work or researches carried out by the Author. It is a review of work carried out under the direction of Professor H. W. Swift—work that has been proceeding along intelligently planned lines for seventeen years or so.

In the course of these extensive investigations a great amount of data and knowledge has been accumulated. Much of this information has been published as individual items in various scientific journals and as papers to a number of learned societies. Up to the present time, however, the results of these investigations have remained scattered and out of reach of the larger proportion of technicians to whom they would be of interest. In this book Willis has, at the request of the committee responsible for the work, made an attempt to collate and review the work of Professor Swift in order that it may be more readily available to the large interested public.

At first sight the book may seem disjointed, and some sections may appear to be unconnected with those preceding or following. The author, however, should not be too severely dealt with on this score, for to crowd into some 134 pages the results of such prolonged investigations is a thankless task. A slight increase in the size of the book, and thereby more continuity, would have been well worth while as an author is not restricted as regards book length.

As has been stated, the book is abstracted from original reports of work carried out, and it does appear that on certain graphs and plots of results the notations obviously refer to items in the original reports but do not appear in the book. Under these circumstances, it would probably have been better to re-draft the figures than to reproduce them directly from the original figures. It would also have been an advantage had the Author drawn conclusions from the work covered by each chapter, and made comparisons or recommendations in the light of industrial experience.

Having levelled these criticisms, serious consideration can be given to the information contained in the pages of this book. The technique of deep drawing has been established so long that the accumulated experience of generations is usually able to provide an answer to any problem encountered. What it is usually unable to do is to say why seemingly impossible shapes can be imparted to sheet metal. This is to admit that deep drawing has so far remained an art rather than become a science. Research workers and scientists have been the first to acknowledge that the progressive technician has always been ahead in providing the answer to "How?". The scientist is now trying to provide the answer to the supplementary question "Why?". The contents of this book represent a serious attempt to supply that answer.

Bearing in mind that this is a review of prolonged scientific investigations, it is not a text-book of formulae for press tool draughtsmen. Much useful information for their guidance, however, will be found in its pages. It is hoped that from the information presented formulae will eventually be developed and a better understanding will be obtained of the mechanics o deep drawing.

Although the designs for the experimental equipment, described in Chapter 1, are not strictly in accordance with tools used in industry generally, the principles on which the designs are based are directly applicable and are therefore worth serious study and consideration. In this connection the Author would have rendered valuable service had he pointed out the usual troubles encountered in the normal press shop when attempting severe drawing operations, using either spring blank-holding or clamp plate blankholding. These methods may be (indeed are) successful when working on the comparatively small size of cup used in these investigations. On large diameter work of even diameter/depth success is not so easily achieved.

The Author wisely points out that Chapters 2 and 6 are academic in nature and may be omitted at a first reading of the book. The reader will be well advised to follow this injunction and so escape mental indigestion. The contents of these chapters are such that gradual absorption is necessary. When the work described in these two chapters is fully understood, it is quite possible that it will point the way to formulation of those simple rules and factors required for tool design. It is to be noted that the deductions drawn from the theory of deep drawing are well in line with logical industrial observations. When careful study is made of the experimental proofs, it will be realised how remarkably close to the apparent ideal has the practical industrial worker arrived. An instance of this will be found in the work

on die edge radii. The investigators have found that the maximum ideal radius is about ten times metal thickness: for years the practical worker has been using about eight times metal thickness as, above this figure, wrinkles tend to form when the blankholder loses control as the metal finally leaves it to flow over the die edge. This is just one instance where the practical man found the way without knowing why.

At a first glance through the book one may be tempted to say that the chapter devoted to the shearing of metal bars and blanks is out of place in a book bearing the title of "Deep Drawing". Second thoughts, however, will reveal the vital importance of this chapter. As a factor influencing the deep drawing of sheet metal too much stress cannot be placed on preparation of the blank. Excessive burr and/or work hardening at the edge of the blank can be the reason for a high rate of failure during the drawing operation, whereas a perfect blank would eliminate the risk of failure.

This book has its shortcomings, but this is inevitable when trying to cover such a vast amount of work in such a short space. Its failings, however, are far outweighed by the accumulation of useful information contained. Altogether it is to be recommended to all those people seriously interested in the fundamental and basic principles of deep drawing. Perhaps foremost among these will be research workers and industrial investigators. Advanced tool designers, too, will find much in it to assist them, if they care to apply basic principles and not blindly follow stereotyped tool designs. For those of an enquiring turn of mind its pages contain much to give them encouragement and the incentive to pursue their own work of investigation and development. J.A.G.

PERIODICALS CURRENTLY RECEIVED

Aero Research Technical Notes. Duxford, Cambridge.
Aircraft Engineering. London.
Aircraft Production. London.
Aluminium Courier. London.
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American Machinist. New York.
Applied Hydraulics. Cleveland.
Aslib Book-list. London.
Aslib Information. London.
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Association Franciaise des Conseils en Organisation Scientifique, Paris. [Bulletin] mensuel.
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Automobile Engineer. London.

B.P.C. Bulletin. London.
B.S.C.R.A. Abstracts. Sheffield.
B.S.I. Information Sheet. London.
Bacie Journal. London.
Ball Bearing Journal. Luton.
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Bibliography of Industrial Diamond Applications. London.
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Books of the Month. London.
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Economist. London.
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Engineer Apprentice and Engineer Student. London.
Engineering. London.
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Engineering Industries Bulletin. London.
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Factory Manager. London.
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Haynes Alloys Digest. International Edition. New York.
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Institute of Metal Finishing, incorporating Electrodepositors' Technical Society, London. Bulletin.
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Ministry of Labour and National Service. Information Service for Editors of Trade and Technical Journals. London.
Ministry of Labour Gazette. London.
Modern Machine Shop. Cincinnati, Ohio.
Modern Materials Handling. Boston.
Monthly Digest of Statistics. London.
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N.R.D.C. Bulletin. London.
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O.R.: Operational Research Quarterly. London.
Occupational Psychology. London.
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Polytechnic Four-Weekly Magazine. Amsterdam.
Power Transmission. London.
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Refa Nachrichten. Darmstadt.
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Tool Engineer. Milwaukee, Wis.
Toolmaker & Precision Engineer. London.
Torque. London.
Trait d'Union. Paris.

V-Belt Journal Hull.

Welding and Metal Fabrication. London.
Werkstatt und Betrieb. Munich.
Werkstattstechnik und Maschinenbau. Berlin.
Whitaker's Cumulative Book List. London.
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Woman Engineer. London.
Work Study Journal. Cheadle, Cheshire.
Works Management. London.

Z.D.A. Abstracts. Oxford.
Zinc Bulletin. Oxford.

NOTICE OF ANNUAL GENERAL MEETING

NOTICE is hereby given that the Annual General Meeting of the Institution will be held at 10, Chesterfield Street, London, W.1, on Thursday, 27th January, 1955, at 4 p.m.

Agenda

1. Notice convening Meeting.
2. Minutes of the Annual General Meeting held on 28th January, 1954.
3. Report on Elections of Members to Council.[1]
4. Annual Report of Council.[2]
5. Presentation of Statement of Income and Expenditure, Balance Sheet and Auditors' Report.[3]
6. Election of Auditors, 1954/55.
7. Election of Solicitors, 1954/55.
8. Vote of Thanks.

By order of the Council.
W. F. S. WOODFORD, *Secretary.*

1. See page 49.
2. See page 50.
3. See page 58.

MINUTES OF THE ANNUAL GENERAL MEETING HELD ON THURSDAY, 28th January, 1954

THE thirty-second Annual General Meeting of the Institution was held on Thursday, 28th January, 1954, at 11 a.m., at the Headquarters of the Institution, 36, Portman Square, London, W.1. The President, Mr. Walter Puckey, Kt., was in the Chair.

Notice convening Meeting

The Secretary (Mr. W. F. S. Woodford) read the notice convening the Meeting.

Notice of previous Annual General Meeting and of Extraordinary General Meeting

The Minutes of the previous Annual General Meeting held on 29th January, 1953, and of the Extraordinary General Meeting held on 17th September, 1953, were taken as read and confirmed on the motion of Mr. R. H. S. Turner, seconded by Mr. R. M. Buckle.

New Articles of Association

On the motion of Mr. G. R. Pryor, seconded by Mr. H. Tomlinson, the new Articles of Association, as set out on pages 56 to 62 of the January, 1954, issue of the Journal, were adopted.

Election of Members to Council, 1954/55

The Report on the Election of Members to Council was received on the motion of Mr. J. Blakiston, seconded by Mr. J. E. Hill.

Annual Report of Council

The President proposed that the Annual Report be taken as read, and asked Mr. G. R. Pryor, Vice-Chairman of Council, to move its adoption.

Mr. Pryor said he had nothing to add to the Report as published in the January, 1954, Journal, except to

assure members that any questions they might raise would be answered. He moved the adoption of the Annual Report of Council.

Mr. E. N. Farrar seconded the motion, and the Annual Report was adopted.

Statement of Income and Expenditure, Balance Sheet and Auditors' Report

On the motion of Mr. G. R. Pryor, seconded by Mr. T. Fraser, C.B.E., the accounts were adopted unanimously.

Election of Auditors, 1953/54

On the motion of Mr. E. Percy Edwards, seconded by Mr. R. Hutcheson, Messrs. Gibson, Appleby & Co., Chartered Accountants, were re-elected Auditors to the Institution and thanked for their services.

Election of Solicitors, 1953/54

On the motion of Mr. H. Peter Jost, seconded by Mr. S. G. Haithwaite, Messrs. Syrett & Sons were re-elected Solicitors to the Institution and thanked for their services.

Votes of Thanks

On the motion of the President, a vote of thanks to his immediate predecessor, Sir Cecil Weir, to Mr. Harold Burke, Chairman of Council, and to Mr. G. R. Pryor, Vice-Chairman of Council, was carried with acclamation.

In response, Mr. Pryor conveyed to the President the warm congratulations of the Council on the honour which had recently been bestowed upon him.

The proceedings then terminated.

REPORT ON ELECTION OF MEMBERS TO COUNCIL, 1954/55

In accordance with Article of Association No. 34, there were eighteen vacancies for elected Members of Council (sixteen Members and two Associate Members).

For the sixteen vacancies for elected Members thirty-five nominations were received. As a result of the ballot conducted in accordance with Article of Association No. 43, the following were elected:

Mr. A. J. Aiers	Mr. F. J. Everest
Mr. H. W. Bowen, O.B.E.	Mr. R. S. Hind
Mr. R. S. Brown	Mr. B. G. L. Jackman
Mr. R. M. Buckle	Mr. R. Kirchner
Mr. A. G. Clark	Prof. T. U. Matthew
Mr. Wm. Core	Mr. A. L. Stuchbery
Mr. B. H. Dyson	Mr. C. Timms
Mr. E. P. Edwards	Mr. R. H. S. Turner

For the two vacancies for the elected Associate Members, eight nominations were received. The two Associate Members elected were:

Mr. R. S. Clark
Mr. B. E. Stokes

Ballot papers were circulated to 5,130 Corporate Members in the United Kingdom. Details of the voting issued by the Institution's Auditors are as follows:

Eligible papers included in the ballot		1225
Rejected:		
Incorrect number of votes recorded	48	
Papers not marked in ink	14	
Spoiled papers	23	
Envelopes unsealed	3	
Paper signed	1	
Paper with other communications enclosed	1	
Insufficiently stamped—returned to G.P.O.	11	
Received from G.P.O. as unable to deliver	6	
Papers received after closing date	101	208
		1433

The full list of Council Members for the current year is published in the Journal.

REPORT OF COUNCIL

1st July, 1953 to 30th June, 1954

TO BE PRESENTED BY THE CHAIRMAN OF COUNCIL AT THE ANNUAL GENERAL MEETING

Thursday, 27th JANUARY, 1955.

I AM happy to place before you what I believe you will consider to be a very satisfactory Report of the Council of the Institution for the year ended 30th June, 1954.

In doing so, may I remind you that during the whole of the period under review the Council was under the Chairmanship of Mr. Harold Burke. The Institution owes a great deal to the drive and initiative of Mr. Burke and I am particularly pleased to be able to report that the enthusiasm he brings and the attention he gives to the affairs of the Institution on a national level, have in no way diminished since he vacated the Chair.

If, at the end of my year of office, my successor is able to report that during the current year we have brought to fruition and consolidated the projects initiated under the Chairmanship of my predecessors, I should indeed feel content, although that does not mean that your Council is not already considering and planning for the next moves ahead as soon as circumstances are favourable and finances permit.

The year 1953/54 will go down in the Institution's history as one of considerable upheaval, for during this year we made a number of major changes in our way of life. These changes come under three broad headings, namely: the change in our constitution when we established the Regional Plan in the United Kingdom; the changes in our qualifications for membership, which have tended to make admission to the Institution more difficult; and thirdly, our move into new headquarters. We committed ourselves to the new constitution and to the changed membership regulations at the Annual General Meeting last year, when we adopted our new Articles of Association. Our proposed move into new headquarters, although a decision of the Council, has already been referred to by previous Chairmen in their reports to the Annual General Meeting. There are many members who had misgivings about these plans and it was suggested by some that we might not be able to see them through successfully. In the case of our new headquarters, I know that there were some members who felt that we should be taking on a commitment far beyond our resources and that we should be struggling for years to recover our financial position, with a consequent serious hampering of our activities. There comes a time, however, in the affairs of all of us when we must proceed as an act of faith and with determination to succeed. Under the inspiring leadership of our immediate Past President, Sir Cecil Weir, and our President, Sir Walter Puckey, we decided to go ahead with our plans, come what may, and our faith was justified, as has been proved in the event.

STANDING COMMITTEES

The Institution is so constituted that the bulk of its routine work is under the control of the various Standing Committees who are elected by the Council. All the Standing Committees have been very active and I will deal with each in turn.

Finance and General Purposes Committee

Your Finance and General Purposes Committee have been keeping a most careful watch on the trend of our income and expenditure and they have kept Council fully informed of our financial progress. The accounts have been circulated with this report and I am sure that you have all studied them very closely. Their adoption is the subject of another item on the agenda and you will be able to ask questions or to make comments, but I should like to take this opportunity of referring to some points of interest.

Our balance sheet has taken on a somewhat different appearance. All our investments have been sold (excepting Fund investments) and in their place we now have under our fixed assets "freehold premises at cost", and the cost of altering and equipping our new building. The figure of £4,964 shown against this latter heading is an interim one, since all the work was not finally completed at the end of the financial year and this item may appear different again in next year's balance sheet.

The response to Sir Cecil Weir's appeal to members to subscribe to the New Building Fund has been of immense help to your Council and I should like to take this opportunity of expressing my personal appreciation to all those members and firms who have helped us by sending donations.

I am sure you will be interested to have a much more detailed and up-to-date picture of these transactions than the balance sheet reveals, and accordingly I have prepared for your guidance a statement of the New Building account as it stands at 1st December, 1954:

New Building Fund

		£
Donations received up to 1st December, 1954		16,296
Sale of Securities		25,108
Sale of Insurance Policies		3,278
Ministry of Works Dilapidation Allowance		2,185
Sale of Leasehold Premises at Portman Square		4,500
Total Capital Available for New Building		£51,367
	£	
Cost of Freehold Premises	35,000	
Cost of Repair Work, Professional Fees and New Furnishings to 1st December, 1954	20,487	
Accounts to be paid approx.	2,800	
Total Expenditure		£58,287
Approximate Deficit		£ 6,920

The acquisition of these new premises has had the effect of increasing the balance sheet value of our fixed assets over last year.

On the opposite side, under the heading "Accumulated Funds and Surplus", there are also some changes. The Viscount Nuffield gift has been restored to its original value of £25,000, which was the amount of Lord Nuffield's gift to the Institution. The balance sheet value of this gift has fluctuated from time to time, as the value of the securities in which it had been invested fluctuated. However, now that the gift has been absorbed in our freehold premises, your Council feel that it should stand at its true figure. The New Building Fund and the Reserve Fund have also been absorbed in the new building and therefore disappear from the balance sheet.

An examination of our current assets against our current liabilities shows a state of technical insolvency, in that the amount of our current assets is less than our current liabilities. This, however, need not cause members any alarm. This position is a fortuitous one, occasioned mainly, as I said before, by the fact that the financial transactions in connection with the acquisition of our new headquarters were not completed at the date of the balance sheet. The Income and Expenditure Account reveals a surplus of income over expenditure of £2,590, which is more than double the surplus of £1,135 in the previous year. I am sure you will agree that to have achieved this surplus during a year of immense activity is very creditable.

I do not propose at this point to refer in any great detail to the figures of income and expenditure, since they are clearly laid out in the printed accounts, but I should be most happy to answer any questions which members might care to ask later in the meeting. There are one or two points, however, to which I should like to direct your attention.

On the expenditure side, you will notice a slight drop in the cost of establishment charges. This is accounted for by the fact that we moved into new headquarters six weeks before the end of the financial year, which brought our expenses under this heading to a temporary end. The expenses for the remaining few weeks or so when we were establishing ourselves in 10, Chesterfield Street, have been absorbed in the general cost of the removal. As our new headquarters are substantially larger than 36, Portman Square, we may expect to see an increase under this heading next year.

Administration expenses also show a small drop, the saving being mainly under the heading of "Travel, Entertaining and Meetings". The principal reason for a saving here was that for almost the whole of the period under review, we were without the services of a full-time Education Officer. Furthermore, the Secretary and his staff have been exercising the utmost economy under this heading. The drop in the expenditure on salaries is also accounted for by the fact that we had no Education Officer during this period.

Our Section expenses also show a saving. During the year, by agreement with Local Sections, we introduced several measures of economy which, although saving the Institution some expense, did not in any way curtail the Local Sections' activities. We may, therefore, truthfully say that our Local Sections have improved their productivity!

The cost of the Journal shows a substantial increase over the preceding year. This is because our new Journal was in force for the whole of the period under review, whereas in the previous period, the new Journal had been published for only six months. Against this, of course, you will observe on the income side a corresponding increase in the Journal receipts. It is gratifying that the figures show the Journal to have made a surplus over the year, but I must point out, of course, that the cost of the Journal shown in the Income and Expenditure Account is only the prime cost of printing and circulating. No proportion of head office overheads is charged to the production of the Journal. I am quite sure that you will all agree that the Journal has more than justified the Council's decision to adopt the new format. In my view it is one of the most attractive and informative technical journals available today.

Turning to the income side, you will notice under Subscriptions an item "Recovery of Income Tax on Subscriptions". Last year this produced £464—against which "nil" is shown in the current accounts. This is explained by the fact that the Inland Revenue had not dealt with the Institution's claim for refund of tax on covenanted subscriptions at the date of the accounts. However, I am very happy to inform you that we have subsequently received a remittance from the Inland Revenue for £2,783 under this heading. In accordance with a previous decision of Council, this amount will not be regarded as income but will be transferred to the special reserve account.

If this item of £464 is allowed for, it will be seen that our income from subscriptions in the current year was almost £600 more than in the preceding year.

The effect of these transactions is, as I have said, that we are able to transfer to the Appropriation Account a sum of £2,590, to which must also be added the profit which we made on the sale of the lease of 36, Portman Square. Against that, we lost a little more than £3,000 on the sale of our various investments, the net effect being that our balance carried forward is increased by £582.

I should like now to direct your attention to the Appendix to the accounts which we have published this year for the first time. As you know, we are required by the Companies Act to incorporate in our published accounts all the accounts for our Sections outside the United Kingdom, and in previous years members have asked for an analysis showing the relation between the United Kingdom accounts and the accounts outside the United Kingdom. In the analysis of the Income and Expenditure Account, therefore, you can see how the figures are distributed. It is interesting to know that in the United Kingdom, we have been able to show a working surplus of £704. The analysis of the current liabilities and assets from the balance sheet shows that whereas the Sections outside the United Kingdom have a very substantial excess of assets over liabilities, the position in the United Kingdom is just the reverse. This seems to me to reveal quite clearly that the burden of responsibility for maintaining the Institution's financial stability rests with the Council in the United Kingdom.

Production Exhibition and Conference

Your Financial and General Purposes Committee were naturally concerned during the year with other matters than the Institution's finances and they gave a good deal of attention to the development of general Institution policy. Much of their work is done in association with the other standing committees, which is reported under various headings, but there was one particular item of activity during the year upon which I should like to comment, namely, the establishment of the Production Exhibition and Conference at Olympia. Although the Exhibition and Conference was held in July 1954 and it is therefore not strictly proper to be dealt with in this report, nevertheless all the work of preparation was done during the period under review. To become involved in an exhibition of the kind held at Olympia was an entirely new departure for the Institution. However, we were able to form a most happy partnership with the firm of Andry Montgomery Ltd., who are experienced exhibition organisers, and they undertook entire financial responsibility for the Exhibition whilst, at the same time, providing the Institution with the facilities to organise the Conference.

The Finance and General Purposes Committee set up a special Exhibition and Conference Committee which had as its terms of reference "to advise the Exhibition organisers and to organise the Conference to run concurrently". The Committee was established under the very vigorous Chairmanship of Mr. M. Seaman, Chairman of the Editorial Committee, and a number of representatives from other organisations were invited to join the Committee. The total strength of the Committee was as follows:—

Chairman: Mr. M. Seaman
Vice-Chairman: Mr. W. J. T. Dimmock

Members of the Institution:—
Sir Walter Puckey, President
Major-General K. C. Appleyard, C.B.E.
Mr. E. G. Brisch
Professor J. V. Connolly
Mr. R. M. Currie
Mr. B. H. Dyson
Dr. D. F. Galloway
Mr. J. O. Knowles
Mr. J. Loxham

British Productivity Council Representatives:—
Sir Thomas Hutton, C.B., M.C.
Mr. T. E. D. Kidd, M.B.E.

Trades Union Congress Representative:—
Mr. E. Fletcher

British Standards Institution Representatives:—
Mr. L. G. Watkins
Mr. S. G. Willby

Department of Scientific and Industrial Research Representative:—
Dr. D. S. Urquhart

Andry Montgomery Ltd. Representative:—
S. D. Cooke

To all these gentlemen I would like to express the Institution's sincere thanks for the remarkably successful way in which this venture was pursued. The Committee had little more than six months from the date they were first convened to the time of the Exhibition and Conference, and there were many who, quite frankly, said that it could not be done. All those who saw the Exhibition and attended the Conference will agree with me that the critics were entirely confounded. A great measure of the success of the Exhibition and Conference was due to the skill and experience of the Directors of Andry Montgomery Ltd. and, in particular, Mrs. M. A. Montgomery and Mr. S. D. Cooke. Tentative plans are being discussed for another Production Exhibition and Conference to be held some time in 1956.

Your Finance and General Purposes Committee were naturally very much involved in the arrangements for the move to our new headquarters. I should like to record here the Institution's appreciation of the work of Major-General K. C. Appleyard, Past-President; The Rt. Hon. Lord Sempill, Past-President; and Sir Walter Puckey, President, who were constituted as a "House Committee" and undertook the task not only of negotiating the purchase of 10, Chesterfield Street, but also of superintending the work of the architect and the decorators. They had the inestimable help and advice of Lady Sempill, who gave a great deal of her time to directing the work of the decorating and furnishing the entrance hall and the public rooms. At the close of the year with which this report deals, their work was still uncompleted, but that they have since restored the building to its full beauty is now for all to see. However, I will leave the end of this story to be told by the Chairman at next year's Annual General Meeting.

Editorial and Papers Committees

The Journal in its new form is now firmly established as one of the leading professional publications,

and has added considerably to the Institution's prestige and status. Much credit is due to the Editorial Committee for their enthusiasm and hard work in this respect. Their constant aim is to improve the Journal still further, both in appearance and content.

In order to ascertain the wishes of members regarding the type of material published in the Journal, a questionnaire was circulated with the June 1954 issue, and met with a good response. Many useful suggestions were received, and are being borne in mind by the Editorial Committee in planning the Journal.

When the new Journal was originally planned, it was thought that it might prove difficult to maintain the Journal at more than a total of 100 pages, of which approximately 55 pages would be devoted to advertising material and 45 pages to editorial. However, the combined efforts of the Editorial and Papers Committees, coupled with increased sales of advertising space, have made it possible to publish a substantially larger Journal and thus to convey to members a great deal more information than hitherto. This has been made possible, whilst maintaining the balance between cost and revenue, which reflects clearly the amount of hard work which the Editorial Committee have invested.

The Papers Committee's main concern, apart from the heavy volume of routine work of reading and assessing the Papers submitted for consideration for publication in the Journal, and for the Institution's Medal Awards, has been the organising of meetings at which the Institution's three Named Papers were presented during the year. You have, of course, all seen the reports of these meetings published in the Journal, but I will refer to them again briefly in order of their presentation:

The 1953 Sir Alfred Herbert Paper was presented by Sir John Cockcroft, Head of the Atomic Energy Research Establishment at Harwell, at the Sheldonian Theatre, Oxford, in July, 1953. The subject was "Industrial Application of Radio-Active Materials". Over 750 members and visitors attended this meeting.

The 1953 George Bray Memorial Lecture was presented at Leeds University on 9th November, 1953, by Sir Harry Pilkington, Chairman of Pilkington Bros. Ltd., and President of the Federation of British Industries. His subject was "The Manufacture of Plate Glass".

The 1953 Viscount Nuffield Paper was presented on the 16th December, 1953, at the Royal Institution, London, by the Right Hon. The Lord Sempill, A.F.C., a Past-President of the Institution, who spoke on "Productivity—Are We On The Right Road?".

During the period under review arrangements were also made for the 1954 series of Papers.

The Papers Committee have felt some concern at the poor quality of some of the papers which have been submitted from Sections. Of the large number of papers which are received at head office and read by the Papers Committee, a comparatively small number are found to be suitable for publication in the Journal. This is not of itself surprising, since many of the Section papers are "repeat performances" and many of the lectures are not intended by their authors for publication. The Papers Committee acknowledge that many of these practical talks are of great interest to members. Nevertheless, it is of the utmost importance that at all meetings of the Institution the material presented, whether as formal papers or practical lectures, should be of the highest possible quality.

Mr. M. Seaman was Chairman of the Editorial Committee throughout the year and he has been re-elected for a further year of office. Mr. W. J. T. Dimmock was Chairman of the Papers Committee. He has now been succeeded in the current year by Mr. K. J. Hume.

Education and Membership Committees

Following upon the adoption of the new Articles of Association, at the previous Annual General Meeting, some doubt was cast on the possible interpretation of Article of Association 15(c), covering the qualifications for admission to Associate Membership. The Council of the Institution have decided that this Article should be interpreted as meaning that *all* applicants for membership over the age of 35 must

either: satisfy the requirements of the Associate Membership examination

or submit a thesis

as the Council shall direct.

Membership Regulations

Following the recommendation of the Membership Committee, the Council have made some modification in the membership and examination regulations. It has been decided that a registration fee of one guinea should be charged on all applications for membership. In the case of successful applications the registration fee is deducted from the first annual subscription, but in the case of unsuccessful applications the registration fee is forfeited. Adjustments have also been made in the thesis assessment fees and in the examination and exemption fees, full details of which are published in the leaflet entitled: "Associate Membership Regulations", available from the Secretary.

Membership

I am happy to be able to report a continued increase in the membership of the Institution. The following table shows the membership on the 30th June, 1954, compared with the membership for the previous year:—

	1954	*1953*
Honorary Members	8	8
Members	1,526	1,484
Associate Members	4,796	4,551
Intermediate Associate Members (this grade ceased to exist on 1st July, 1953)	—	76
Associates	162	157
Graduates	2,077	2,006
Students	1,064	963
Affiliated Firms	203	198
Total Membership 30th June, 1954	9,836	9,443
Net increase	393	

During the year, the Membership Committee gave consideration to 1,406 applications for membership.

In passing, I am sure you will be glad to know that during the current year our membership has exceeded the 10,000 mark.

Education Committee

The Education Committee have given considerable attention during the year to the examination structure and they have appointed a special sub-Committee to deal with the many applications which are received for exemption from the Institution's examinations. The Committee wish to record that during the year, the Institution of Mechanical Engineers have notified the Institution that they have decided to recognise subjects taken in our Associate Membership examination as providing exemption from equivalent subjects in the examinations of the Institution of Mechanical Engineers.

The Education Committee are giving extended consideration to the syllabus of the Institution's examination. Although in principle the Council of the Institution have adopted the policy of "Broadening the Base", the Institution's present examination syllabus makes it virtually impossible for anyone who is not trained as a mechanical engineer to enter the Institution. The Education and Membership Committees have jointly been considering the report of the special sub-committee which was appointed to submit proposals to implement the "Broadening the Base" policy. This report has also been circulated to Section Committees for their consideration. Following these discussions, a revised examination structure has been suggested, which has been accepted in principle by the Council of the Institution. The Education and Membership Committees, with the assistance of the Local Sections, are now jointly engaged on working out the practical details of the scheme.

Examination Regulations

A small change in the regulations for admission to the Institution's examinations has been made. Hitherto candidates were not allowed to sit for the examination unless they were otherwise qualified for membership in all other respects. It has now been decided that candidates may be given permission to sit for the Institution's examination even if they might not otherwise be qualified for membership, on the clear understanding that success in passing the examination does not *of itself* qualify the candidate for admission to the Institution.

Institution Representatives on Other Bodies

The Education Committee has continued to nominate representatives of the Institution to serve on other bodies. Among those bodies upon which the Institution is represented may be mentioned a number of National Advisory Councils and Regional Advisory Councils for Further Education; the governing bodies of the City and Guilds of London Institute; Loughborough College and a number of other technical colleges; the Parliamentary and Scientific Committee; and other similar bodies.

Production Engineering in Canada

One of the major obstacles to the Institution's progress in Canada is the lack of facilities for studying production engineering. Negotiations have been conducted with the Ryerson Institute of Technology in Toronto and there is every promise that these negotiations may result in the establishment of courses leading to the Institution's examinations.

Associate Membership Examination

The 1954 examination was set during the last two weeks of May. The total number of candidates was 220, which shows an increase of 33 over the previous year. Of this number, 19 sat for the examination at centres outside the United Kingdom. Approximately 56% of the candidates were successful in passing the examination, details of which have already been published in the Journal.

Summer School

The Summer School was held at Ashorne Hill in August 1953 and the subject chosen was Work Study. The attendance was over 100 members and visitors and the high standard of previous Summer Schools was still maintained.

Mr. H. W. Badger, M.A.

Both the Education and Membership Committees welcome the appointment of Mr. Badger as Education Officer. In the short time that he has been a member of headquarters staff, Mr. Badger has already proved himself to be a valuable member of the secretariat.

Although the Education and Membership Committees have a considerable volume of work which is quite separate one from the other, their work is nevertheless very closely related. Not the least important of the Education Officer's functions is to provide a continuous liaison between the two Committees.

Mr. S. A. J. Parsons was Chairman of the Membership Committee during the year under review and he has been re-elected for a further term of office. The Chairman of the Education Committee throughout the year was Principal C. L. Old, who has also been re-elected for a further year of office.

Hazleton Memorial Library Committee

Of all the departments of the Institution, the Library is the one which has gained most from the move to new headquarters. Instead of a reading room which could not be used whenever meetings were in progress, and a tiny office hidden round a corner, there is one of the loveliest rooms in the building available for members' use at all times, as well as much increased office and storage space. There is still much to look forward to, as the furnishing of the Library is not yet complete, and the shelving will have to be extended as soon as finances permit. The Committee are now anxious that members shall be aware of the facilities at their disposal, and shall take advantage of them. The opening of the Library during London Graduate Section Lecture Meetings has been much more worthwhile since the increased space has been available.

The second item of major importance as far as the Library is concerned is the compilation of the catalogue. Additional assistance was obtained for the work, and progress has been steady, though there was far more involved than was anticipated. The completion of the subject catalogue has greatly facilitated the day-to-day work of the staff, and the Library Committee feel sure that it will, when published, be of great value to members.

The demands on the Library have been greater than during the previous year, and enquiries have been received on subjects as diverse as Shell Moulding and Automatic Computing Machines; Machinery Replacement Formulae and Machinability Ratings; Ultrasonic Cleaning and Incentive Schemes. The number of members calling personally has increased slightly, though the majority of business continues to be done by post and telephone. Friendly relations are maintained with the National Central Library, the Science Library, A.S.L.I.B., and with many special libraries, and a large number of members have benefited from the fact that books and periodicals, not otherwise available to them, have been obtained from these sources.

The Library Committee have lost the services of Messrs. R. Thorn and L. J. Saunders, who have had to resign through pressure of other work, but have been strengthened by the co-option of Messrs. R. C. Renton, A.M.I.E.D., A.M.I.Prod.E., and M. J. Sargeaunt, A.M.I.Prod.E. Lord Sempill was re-elected Chairman of the Committee, and Mr. J. C. Z. Martin, Vice-Chairman and Chairman of the Book Selection Sub-Committee.

Great assistance has once again been given by members in all parts of the country in the reviewing and abstracting of books added to the Library. To them, the Committee expresses its sincere thanks.

Research Committee

The Research Committee are particularly pleased to report that their assistance is increasingly being sought by other organisations in connection with their research work. During the year under review, the Committee have thus been called upon for advice and assistance by two Universities, Edinburgh and Southampton: at the latter, an investigation is being made into the impact on British economy of American-originated companies operating in the United Kingdom; at Edinburgh, an investigation is being made of inspection in industry.

The two sub-Committees appointed by the Joint Committee of the Institution and the Institute of Cost and Works Accountants to study the question of Production Control, continued during the year, under the Chairmanship of Mr. F. G. S. English. It is hoped that their final report will be published early in 1955. The report will comprise a summary of the replies to questionnaires sent by the Committee to a wide variety of firms in this country, and a detailed statement of the principles and practices underlying effective production control, with special reference to the smaller firm.

The Materials Handling Sub-Committee of the Research Committee, during the year, continued their review of the case studies on materials handling in the United Kingdom and initiated a further investigation into the Cost of Handling. A good deal of the Committee's time during the period was devoted to preparation for the Materials Handling Conference which was held in October, 1954, and of which a fuller report will be given in the Annual Report for the current year.

The Materials Utilisation Sub-Committee have spent the greater part of the year in collecting and collating over 100 case studies of successful attempts to improve materials utilisation. Their report will, it is hoped, be published early in 1955. The present series of case studies has been concerned only with the light engineering and metal-working industries, but during the current year the Sub-Committee intend to extend their activities to other industries.

During the year, the Research Committee appointed another Sub-Committee with the following terms of reference:

> "To prepare a guide, to be published by the Institution of Production Engineers, giving a comprehensive list of sources of information available to the Production Engineer; to encourage Production Engineers to *use* existing sources of information".

The Sub-Committee did not begin their work until the end of the year under review, but it is hoped that the Directory of Sources of Information will be published during 1955.

The Research Committee have initiated an investigation into the research projects undertaken by other bodies, with a view both to proffering the assistance of the Institution where suitable and of avoiding duplication of work.

The Chairman of the Committee, Mr. B. H. Dyson, represented the Institution on the International Management Conference Committee, which was responsible for the European Management Conference held in October, 1954.

During the year, the Research Committee also considered whether the problem of incentives could be dealt with by the Institution, but it was decided that since this would be a matter primarily for the Joint Committee of the Institution and the Institute of Cost and Works Accountants, work on this project should not be begun until after the publication of the Report of that Committee.

The Chairman of the Research Committee during the period under review was Mr. B. H. Dyson, and Mr. F. G. S. English was Vice-Chairman. Mr. Dyson and Mr. English have been re-elected for a further year of office.

Standards Committee

The Standards Committee have continued their work in close collaboration with the British Standards Institution, and at present are represented on 120 B.S.I. Technical Committees.

During the year twenty-nine British Standards Specifications have been received and discussed and the recommendations of the Standards Committee have been passed to the B.S.I.

Mr. C. M. Holloway was Chairman of the Committee during the year and his place has now been taken by Mr. R. E. Mills. Mr. W. E. Wright has been elected Vice-Chairman.

The Standards Committee during the year received a number of suggestions for proposed Standards and altogether thirteen suggestions were forwarded to the B.S.I. One of the suggestions received was that Standards Engineers should meet to discuss their problems and difficulties, and the Standards Committee hope, with the co-operation of the British Standards Institution, to arrange such a conference during 1955.

During the year, Mr. J. H. Winskill represented the Institution at the International Conference for the Standardisation of Machine Tools held in London from May 10th-20th, 1954.

Awards

On the recommendation of the Papers Committee, the following awards for papers were made during the year:—

Institution Medal for the Best Paper presented to a Section by a Member: To Mr. F. G. Woollard, M.B.E., M.I.Prod.E., for his Paper on "The Advent of Automatic Transfer Mechanisms".

Institution Medal for the Best Paper presented to a Section by a Non-Member: No award this year.

The Hutchinson Memorial Award (for the Best Paper presented to a Section by a Graduate): To Mr. L. K. Lord, for his Papers:—"The Nature of Tungsten Carbide" and "The Technique of Carbide Tooling".

Schofield Travel Scholarship: The Awards Committee regretted that the standard of entry was such that no scholarship could be awarded for 1953.

Lord Austin Prize: The 1953 prize was awarded to Mr. David Whitehead of Liverpool for his essay entitled:—"Incentive Systems".

Local Section Activities

It has always been the policy of the Institution to "take the Institution to the members", and wherever a sufficient number of members has justified the course a Local Section has been established. On the 30th June, 1954, there were thirty-eight Sections in the United Kingdom, with twelve Graduate Sections, whilst eight Sections were established outside the United Kingdom:—Australia: Adelaide, Melbourne and Sydney; Canada; India: Bombay and Calcutta; New Zealand; South Africa.

The officers of Local Sections met in the U.K. on a Regional basis during the year, in order to prepare the way for the establishment of the Regional Plan, which came into force on the 1st July, 1954.

During the period under review, membership in the Local Sections has continued to increase and local activities have been varied and interesting. In addition to the 340 lecture meetings held in the United Kingdom, and 50 in the Sections outside the United Kingdom, there have been many successful dinners and dances, and social functions; also a number of interesting film shows and works visits have been held.

The U.K. Regional Plan which came into operation this year has proved to be a significant step in the growth of the Institution. Most Regions have arranged one or two Regional Meetings for this Session, and those that have already been held have proved to be very successful. All Sub-Sections have now been granted full Section status, and new Sections have been established in Tees-side and Doncaster. Negotiations are still continuing for the formation of a Section in Pakistan, and the Institution now has Corresponding Members in Israel, Egypt and British West Africa.

A second Conference on "Problems of Aircraft Production", organised by the Southern Section, was held in Southampton. This Conference was very well attended and maintained the high standard set at the first Conference. These Conferences on Aircraft Production have demonstrated how a Local Section, with the help and support of head office, can organise a highly successful occasion. I hope that some of the Regions will follow the example set at Southampton.

At the Section Honorary Secretaries Conference held in May various administration problems were discussed, and, as usual, this Conference proved its usefulness in maintaining the good relations which exist between Section Honorary Secretaries and head office.

The Graduate Sections still continue to take a very active part in the affairs of the Institution. The London Graduate Section and the Halifax Section have held Week-End Schools, both of which were well attended. A One-Day Convention was arranged by the Birmingham Graduate Section, who also organised a very successful Industrial Tour of Germany. The Fourth Graduate Representatives Conference was held this year in Coventry.

Visitors

A number of members from Sections outside the United Kingdom have visited us during the year and have shown great interest in the new headquarters. Members from Great Britain have also visited various parts of the Commonwealth, where they received a very warm welcome.

Honours

It is recorded with very great pleasure that the following members have been honoured by Her Majesty The Queen during the year:—

A. H. Blackwell, M.B.E.
J. Buckley, M.B.E.
F. R. Charlton, M.B.E.
E. W. Field, O.B.E.
F. Grimshaw, O.B.E.
J. Hastings, M.B.E.
A. J. Perkins, O.B.E.
W. C. Puckey, Knight Bachelor
G. H. Rippon, M.B.E.
Miss A. G. Shaw, C.B.E.
W. C. Swift, O.B.E.
F. T. West, M.B.E.

Obituary

It is with regret that the deaths of twenty-five members during the year must be recorded. Their names have been published in the Journal.

Council Meetings

Your Council have met four times during the year. The change in the order of dealing with the business, which was introduced last year, has been continued.

Under this arrangement, the Council are able to dispose of the routine business by mid-day, thus having the afternoon session available for discussion of particular points of Institution higher policy. During the year, Council have had lengthy discussions on:—

1. Review of Harrogate Conference 1953 and discussion on future Institution Conferences.
2. New Building arrangements.
3. Implementation of the new Articles of Association.
4. Royal Charter prospects.

Services of Members

When referring to the work of the Hazleton Memorial Library, I mentioned the valuable services which members rendered to the Library. I should like also to record the Council's appreciation of the very considerable services rendered to the Institution by many members during the course of the year. It is interesting to reflect that of the Institution's total membership of approximately 10,000, almost 1,000 members are engaged in some active work for the Institution through the medium of Committees and similar activities. Undoubtedly the Institution's high level of activity is very largely due to this major contribution which is made by the members.

Headquarters Staff

I am glad to have this opportunity of paying tribute to the Institution's Secretary. Mr. Woodford has a combination of qualities which are rarely found in any one man and which make him ideally suited to the position he holds. On all social occasions he is greatly helped by the gracious presence of Mrs. Woodford.

We are equally fortunate in his first-line lieutenants—Miss Bremner, Mr. Badger and Mr. Caselton—and in turn by the support given to them by their staffs not only in their normal work, but particularly during the difficulties and irritations inseparable from the removal of the office to our new headquarters.

Nevertheless, they have been somewhat handicapped by an excessive turnover of junior staff which has placed altogether too great a load on the seniors. This appears to be a problem which many organisations in London are facing. The F. & G.P. Committee have this problem actively under review at the moment.

During the year, Mr. H. W. Badger, M.A., as has already been mentioned, joined the staff as Education Officer. Miss H. M. Townley, B.Sc., has come to take charge of the secretarial administration of our various technical committees and Miss F. Grover, B.A., has joined the staff as Mr. Woodford's Secretary.

The Council would like to place on record its appreciation of the services of Mr. C. Barker, who is in charge of the Printing Department, and who has now completed 21 years' continuous service with the Institution.

We were very sorry to lose the services of Mrs. M. Ingram, who joined the staff straight from school and after nearly 10 years' service left us on her marriage.

The President

Not only Council, but all members of the Institution, were delighted when the Queen honoured the President, Mr. W. Puckey, by the conferment of a Knighthood in January, 1954. Sir Walter Puckey has given unsparingly of his time and energies to the Institution. His strong and decisive leadership has had an effect on the course of the Institution's affairs from which we shall receive permanent benefit. Your Council were extremely gratified when Sir Walter accepted the invitation to continue for a second year of office. He is a "Production Engineer" in the very best sense of the word and is a continual source of inspiration to us all. Sir Walter is a man whose whole life is directed by a strong sense of public duty and I feel very strongly that the corporate life of our Institution should be imbued with the same sense of responsibility. We should not concern ourselves too much with the "dignity" or "status" of our Institution: the only justification for the Institution's existence is the extent to which its influence can be exerted in industry for the public good. Dignity and status can be earned only by hard work.

As individuals practising our profession, and as constituent members of a corporate body, we have a responsibility to make the utmost contribution to our national well-being. Only by accepting our responsibilities wholeheartedly shall we earn and deserve the respect and esteem of our fellows.

THE INSTITUTION OF PRODUCTION ENGINEERS

BALANCE SHEET as at 30th JUNE, 1954.

1953 £	1953 £		£	£
		Accumulated Funds and Surplus		
25,027		The Viscount Nuffield Gift	25,000	
500		The Lord Austin Prize Fund ...	500	
100		The Hutchinson Memorial Fund ...	100	
500		The George Bray Memorial Fund ...	500	
2,105		New Building Fund	—	
	28,232			26,100
	3,108	Reserve Funds		—
	464	Special Reserve		464
	921	Life Subscriptions: *Less* amount transferred to Income and Expenditure Account		895
	10,070	Income and Expenditure Account ...		10,652
	42,795			38,111
	—	Hazleton Memorial Library Catalogue		250
	52	Melbourne Prize Account		56
	305	Schofield Scholarship		235
	—	Production Exhibition and Conference		500
	—	Work Study Symposium: South Africa		76
		Current Liabilities		
5,983		Sundry Creditors	16,646	
347		Subscriptions Received in Advance ...	313	
3,520		Bank Overdraft: *Less* Sections and Cash Balances	49	
	9,850			17,008
	£53,002			£56,236

1953 £	1953 £		£	£
		Fixed Assets		
3,500		Freehold Premises: At cost ...		35,000
—		New Building: Cost of Alterations and Equipment, *less* Donations, Reserves, etc.		4,964
3,481		Leasehold Premises		—
		Furniture, Fittings and Plant at the net amount standing in the Institution's books at 30th June, 1948	1,531	
		Additions	4,458	
			5,989	
		Less Depreciation to date	2,362	
3,988				3,627
28,232		Fund Investments at cost: as scheduled (Market Value £1,194)		1,100
3,108		Sinking Fund Policies		—
	42,309			44,691
		Current Assets		
7,856		Sundry Debtors, Deposits and Stocks	9,529	
1,135		General Investments at cost	—	
1,650		United Building Society—Deposit (South Africa)	2,016	
52		Cash at Bank: Melbourne Prize Account	—	
	10,693			11,545
	£53,002			£56,236

WALTER PUCKEY, *President.*

H. BURKE,
Chairman of Council and Finance Committee.

W. F. S. WOODFORD, *Secretary.*

Report of the Auditors to the Members of The Institution of Production Engineers

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by The Institution so far as appears from our examination of those books. Audited Balance Sheets and Accounts have been received from each of the Overseas Sub-Councils and these have been incorporated in the above Balance Sheet and annexed Income and Expenditure Account. We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of account audited by us and the audited Sub-Councils' Accounts supplied to us. The Auditor to the Bombay Section has reported a shortage of Rs. 419 8 0 in the Cash and Bank Balances. In our opinion and to the best of our information and according to the explanations given us the said Accounts give the information required by the Companies Act, 1948, in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institution's affairs as at 30th June, 1954, and the Income and Expenditure Account gives a true and fair view of the excess of Income over Expenditure for the year ended on that date.

20, Bloomsbury Square,
London, W.C.1.

10*th November*, 1954.

GIBSON, APPLEBY & CO.,
Auditors.
Chartered Accountants.

INCOME AND EXPENDITURE ACCOUNT for the Year ended 30th JUNE, 1954.

1953 £	1953 £		£	£
		To **Establishment Charges**		
699		Rent and Rates	591	
1,118		Light, Heat and Cleaning ...	1,259	
453		Repairs and Renewals	289	
—	2,270		—	2,139
		,, **Administration Expenses**		
1,394		Postage and Telephone	2,156	
3,959		Printing and Stationery	3,648	
262		Professional Charges and Insurance	364	
200		Audit Fee	200	
2,381		Travel, Entertaining and Meetings (other than Sections) ...	1,475	
213		Miscellaneous	420	
—	8,409		—	8,263
	16,022	,, **Salaries**		14,874
		,, **Section Expenses**		
2,078		United Kingdom	2,209	
2,225		Overseas (Audit Fees £98) ...	2,499	
2,117		Central Services	1,162	
—	6,420		—	5,870
		,, **Journal**		
16,735		,, Printing	23,056	
1,977		Postage and Envelopes	2,465	
507		Reporting	222	
—	19,219		—	25,743
	—	,, **Institution Papers**		251
	327	,, **Hazleton Memorial Library** ...		421
	245	,, **Donations and Grants**		208
		,, **Miscellaneous**		
—		Annual Dinner, 1953	338	
231		Exhibition Expenses	—	
—		Year Book	426	
95		Summer School	100	
—	326		—	864
		,, **Provisions**		
542		Depreciation—Furniture and Fittings	567	
100		Dilapidations Reserve	—	
127		Leasehold Sinking Fund... ...	—	
—		Hazleton Memorial Library Catalogue	250	
—		Production Exhibition and Conference	500	
—	769		—	1,317
	1,135	,, **Balance**—Excess of Income over Expenditure carried down ...		2,590
	£55,142			£62,540

1953 £	1953 £		£	£
		By **Subscriptions**		
28,516		Renewals and Arrears	28,832	
388		Transfers	311	
1,543		New	1,360	
3,730		Overseas	4,311	
887		Entrance Fees	796	
464		Recovery of Income Tax on Subscriptions	—	
—	35,528		—	35,610
	1,075	,, **Interest**		804
	18,373	,, **Journal Receipts**		26,078
	91	,, **Sale of Publications**		48
	75	,, **Surplus on Annual Dinner, 1952**		—
	£55,142			£62,540

APPROPRIATION ACCOUNT

1953 £		£
464	To Transfer to Special Reserve (Tax recovered on subscriptions)	—
—	,, Loss on Sale of Securities	3,027
10,070	,, Balance carried forward	10,652
£10,534		£13,679

1953 £		£
9,399	By Balance at 1st July, 1953	10,070
1,135	,, Excess of Income over Expenditure brought down	2,590
—	,, Profit on Sale of Lease	1,019
£10,534		£13,679

INVESTMENTS, 30th JUNE, 1954.

	£ s. d.	£ s. d.
The Lord Austin Prize Fund		
£95 8s. 5d. $3\frac{1}{2}\%$ War Stock	83 14 8	
£575 8s. 3d. London County 3% Consolidated Stock, 1920	437 6 10	
		521 1 6
The Hutchinson Memorial Fund		
£95 8s. 5d. $3\frac{1}{2}\%$ War Stock		83 14 8
The George Bray Memorial Fund		
£775 0s. 9d. London County 3% Consolidated Stock 1920		589 0 0
		£1,193 16 2

APPENDIX

THE INSTITUTION OF PRODUCTION ENGINEERS

ANALYSIS OF ACCOUNTS—Year to 30th JUNE, 1954.

INCOME AND EXPENDITURE ACCOUNT

		£	£
Expenditure			
United Kingdom			57,431
Outside the U.K.:	Australia	1,122	
	Bombay	255	
	Calcutta	295	
	Canada	220	
	New Zealand	6	
	South Africa	621	
		——	2,519
Excess of Income over Expenditure			
United Kingdom			704
Outside the U.K.:	Australia	642	
	Bombay	26	
	Calcutta	258	
	Canada	282	
	New Zealand	92	
	South Africa	586	
		——	1,886
			£62,540

		£	£
Income			
United Kingdom			58,135
Outside the U.K.:	Australia	1,764	
	Bombay	281	
	Calcutta	553	
	Canada	502	
	New Zealand	97	
	South Africa	1,208	
		——	4,405
			£62,540

ANALYSIS OF CURRENT LIABILITIES AND ASSETS

	United Kingdom £	*Outside U.K.* £
Current Liabilities		
Sundry Creditors ...		
United Kingdom	16,198	
Outside United Kingdom		448
Subscriptions Received in Advance		
United Kingdom	159	
Outside United Kingdom		154
Bank Overdraft		
United Kingdom	3,766	
	£20,123	£602

	United Kingdom £	*Outside U.K.* £
Current Assets		
Sundry Debtors, Deposits and Stocks		
United Kingdom	9,478	
Outside United Kingdom		51
Investments		
South Africa		2,016
Cash at Bank and in transit		
Australia		1,716
Bombay		67
Calcutta		624
Canada		133
New Zealand		399
South Africa		777
	£9,478	£5,783

INSTITUTION PUBLICATIONS

" THE JOURNAL "

Sent each month to members and representatives of Affiliated Firms. Price to non-members, 10s.

" ACCEPTANCE TEST CHARTS FOR MACHINE TOOLS "

Parts I, II, III and IV. Price 6s. each part.

" PRACTICAL DRILLING TESTS "

Price £1 1s. 0d.

" ORGANISATION AND CONTROL OF PRODUCTION "

Price 5s.

" MEASUREMENT OF PRODUCTIVITY "
(Interim Report).

Joint Committee of Institution of Production Engineers and Institute of Cost and Works Accountants. Price 1s. 6d.

" MEASUREMENT OF PRODUCTIVITY—APPLICATIONS AND LIMITATIONS "

Joint Committee of Institution of Production Engineers and Institute of Cost and Works Accountants. Price 2s.

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" AN EXPANSIONIST POLICY FOR PRODUCTION "

Series of Leading Articles reprinted from the Institution of Production Engineers Journal, January/May, 1953. Price 2s. 6d.

1954. Report Of
" PRODUCTION CONFERENCE "

Olympia. Price £1 1s. 0d.

The Sir Alfred Herbert Paper, 1952—
" THE DEVELOPMENT OF ENGINEERING METROLOGY "

by F. H. Rolt. Price 5s.

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" PROBLEMS OF AIRCRAFT PRODUCTION "

Price 10s.

" THE MANUFACTURE OF COMPONENTS FROM POWDERED METALS "

by W. D. Jones. Price 2s. 6d.

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" PRACTICAL TRAINING IN PRODUCTION ENGINEERING "

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All the above may be obtained from Head Office, post free, with the exception of the Measurement of Productivity Reports, " Applications and Limitations " and " Work Study, Application and Training " which should be ordered direct from the Sole Distributors, Gee & Co. (Publishers) Ltd., 27/28, Basinghall Street, London, E.C.2.

In addition, the following Institution publications may be obtained from the Production Engineering Research Association of Great Britain, Staveley Lodge, Melton Mowbray, Leicestershire.

" ACCURACY IN MACHINE TOOLS "

Price 3s. 3d.

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" PRODUCTION ENGINEERING RESEARCH "

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1954/55

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Secretary of the Institution

W. F. S. Woodford

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CANADA

Canada	P. M. Wood, 31 Conway Avenue, Toronto, 10, Ontario.

INDIA

Bombay	E. Fernandes, c/o Burmah Shell, Royal Insurance Bldg., 14 Jamshedi Tata Rd., Churchgate, Bombay.
Calcutta	N. N. Sen Gupta, 110 Surrendra Nath, Banerjee Road, Calcutta 13.

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Western	A. Eustace, 19 Ferndale Road, Northville, Bristol 7.
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Wolverhampton	R. J. Sury, Wolverhampton and Staffordshire Technical College, Wolverhampton.
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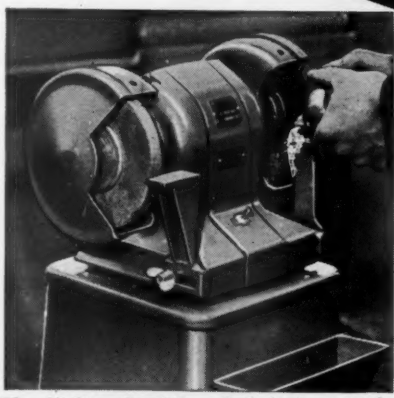
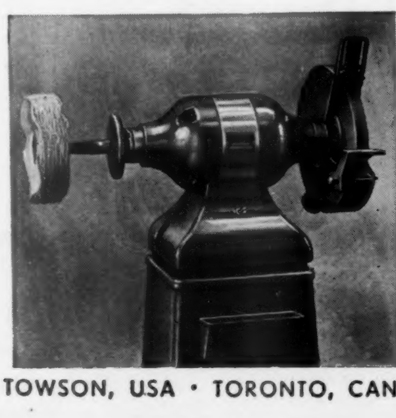
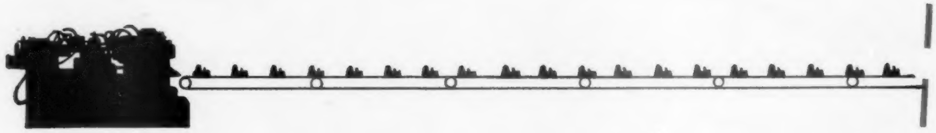




Convert existing machines

to automatic operation



—and watch your output figures soar! Conversion to full or semi-automatic working by means of MAXAM pneumatic equipment, costs only a small fraction of the capital value of the machine or process involved. Yet the effect is enormous—our clients are gaining anything from 100% to 600% increased production. **MAXAM conversion means much more output at much lower costs.**

Such conversion may completely solve your problems. If, however, you are developing new machines or new systems we strongly advise you to call in MAXAM right from the start. We have been partners in the design of some outstandingly successful automatic processes.

As today's most up-to-date production technique, MAXAM is being adopted in many different industries all over the country—may we send you a descriptive leaflet or a catalogue?

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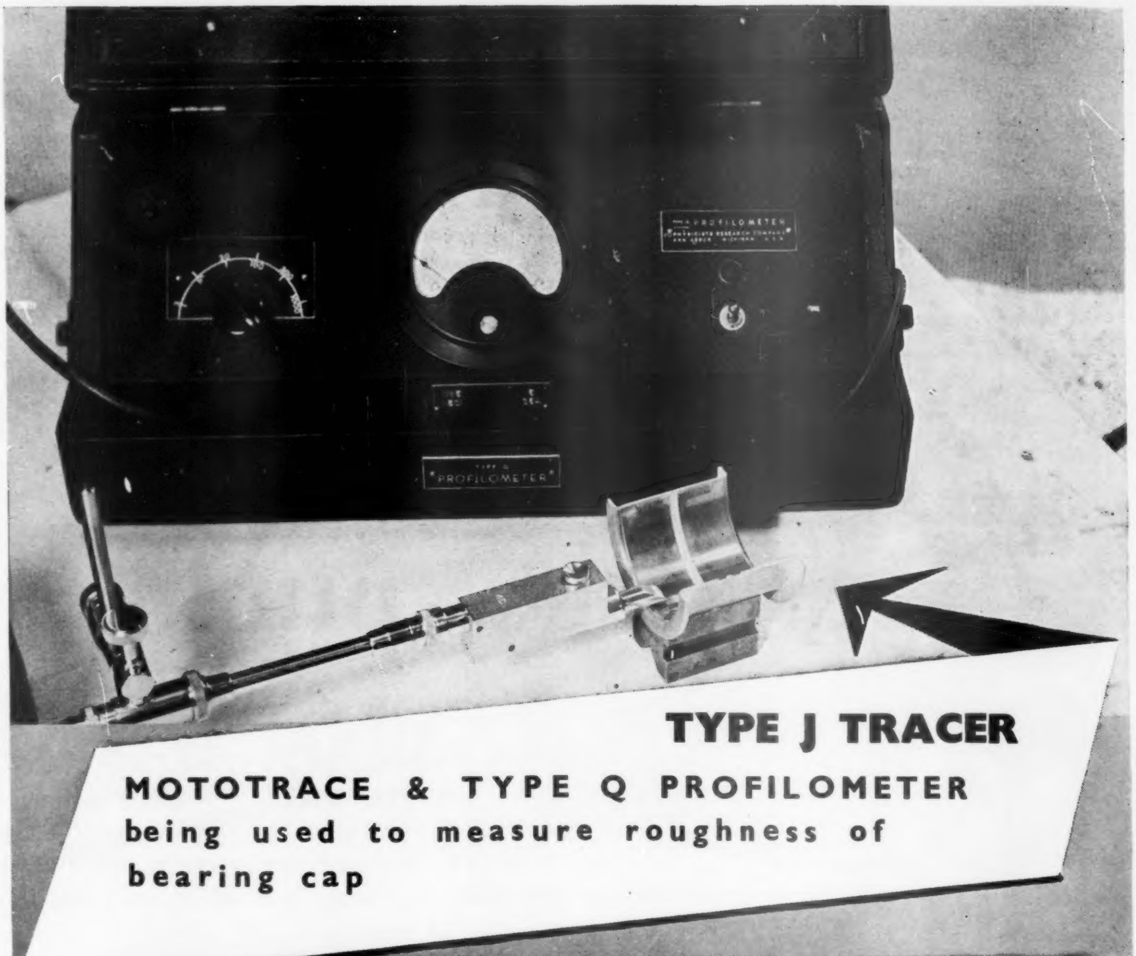
and for your job too—

MAXAM
PNEUMATIC
SYSTEM

TAS/CX 561



The Type J Tracer can be used with any Profilometer Amplimeter, with any Mototrace, and with any Linear Pilotor that has a post for attaching the Linkarm.

THE TYPE J TRACER is designed primarily for taking surface roughness measurement in straight or tapered holes as small as $\frac{1}{2}$" i.d., to a depth of $\frac{7}{8}$", and on gear teeth as small as 10. D.P. It is also used in holes of $1.\frac{7}{16}$" i.d., or larger to any desired depth; on o.d's from $\frac{1}{4}$" to $1.\frac{1}{8}$"; and on flat surfaces. This wide working range is provided by means of interchangeable Skidmounts.

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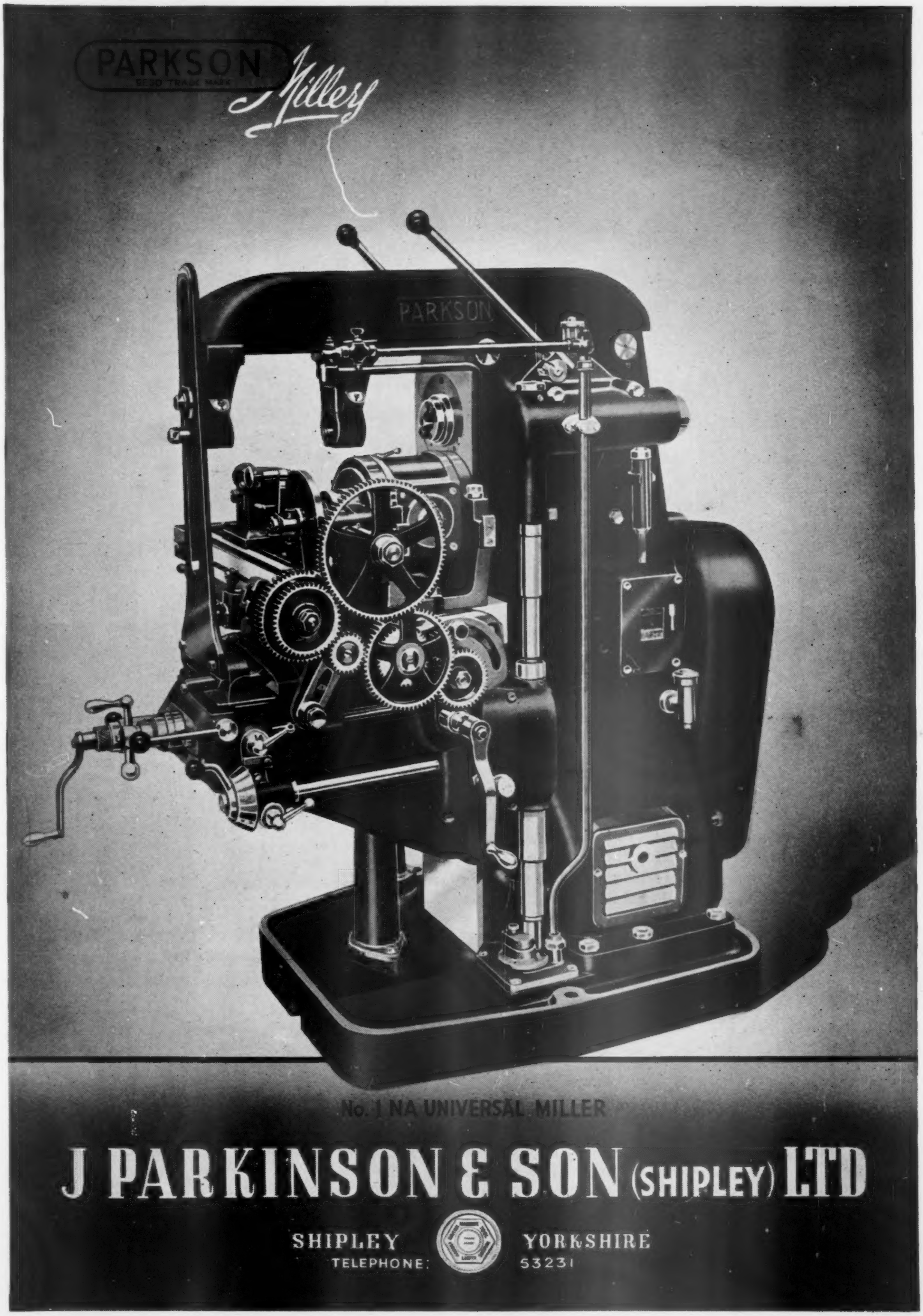
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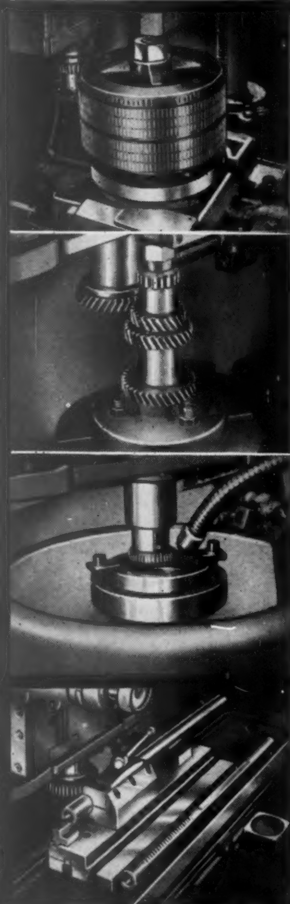
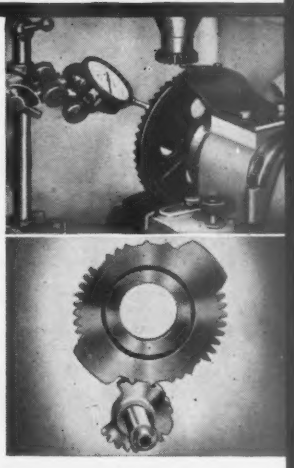
adaptability in gear production



VERTICAL GEAR GENERATING MACHINES **MODEL V10A**

SYKES

External and internal spur and helical gears; splines, serrations and special forms can all be generated at high production rates yet with the greatest accuracy. These machines are automatic in operation and there are no cams to change — rapid set-up is effected by simple adjustment of 2 rollers, reducing idle time to a minimum. Quickly interchangeable rack and contrate gear attachments still further extend the scope of these machines.



V10A max. dia. 14 in. x $2\frac{1}{4}$ in. face and racks up to 36 in. long.

V4 max. dia. $4\frac{1}{8}$ in. x $\frac{7}{8}$ in. face and racks up to 6 in. long.

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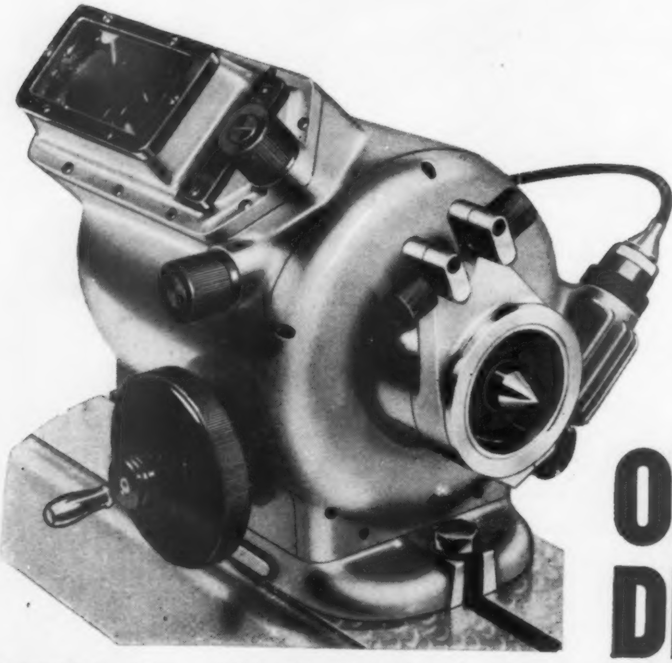
Makers of a wide range of Backstands, Bandfacers, Grinders, etc.

rjh 3595



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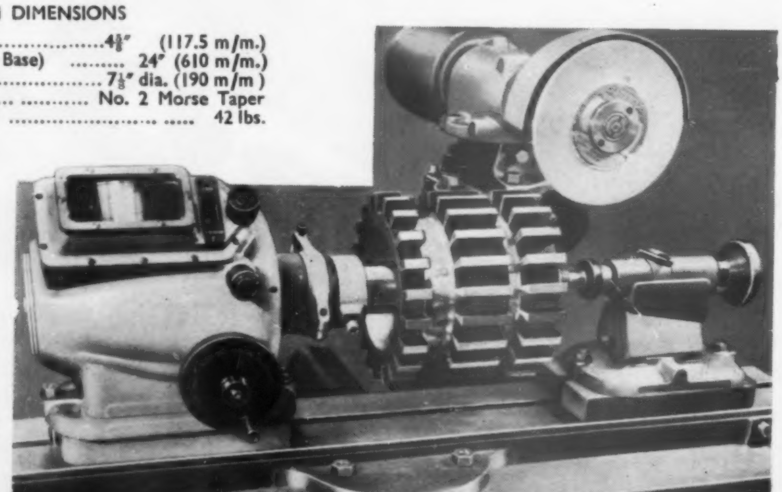
Combining the following features: Dead centre, adjustable drive for zero settings, large vernier screen reading direct to 6 secs. (estimation 3 secs.) and conforms to N.P.L. Specification MOY/SCMI/56.

MAIN DIMENSIONS

Height of Centres	$4\frac{5}{8}''$	(117.5 m/m.)
Centre Distance (on Base)	24″	(610 m/m.)
Size of Face Plates	$7\frac{1}{2}''$ dia.	(190 m/m)
Size of centres	No. 2 Morse Taper	
WEIGHT OF HEAD	42 lbs.	



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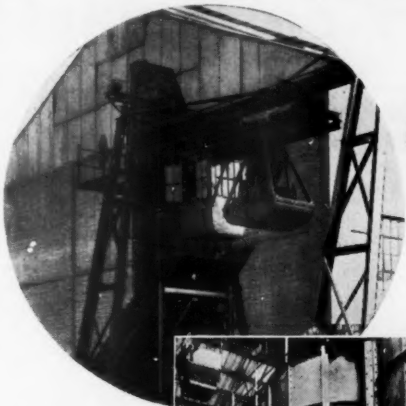
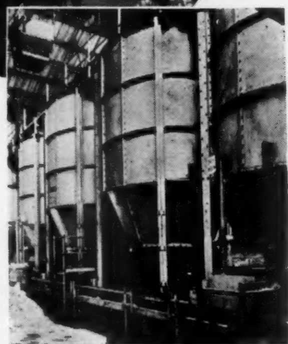
A SUBSIDIARY OF GEORGE H. ALEXANDER MACHINERY LTD. **82-84 COLESHILL ST., B'HAM. 'Phone ASTON CROSS 3264**



Complete Telpher Installations



Sand Storage Hoppers

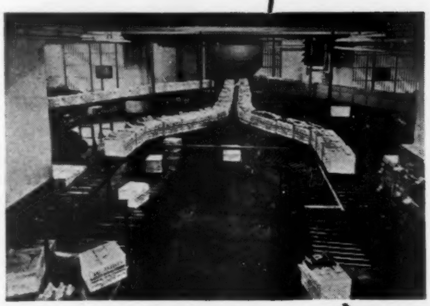
Portable Conveyor

Pallet Conveyors

Something worth knowing

Paterson Hughes Mechanical Handling Systems are used in almost every industry in the world.

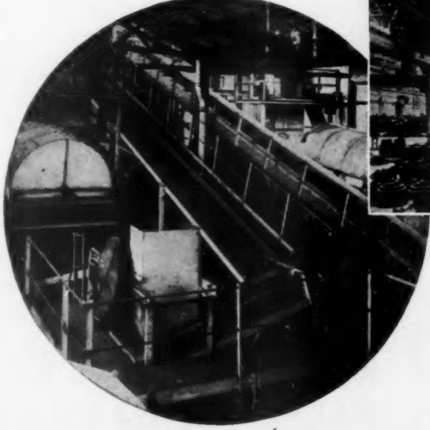
Portable Sack Elevator



Roller Conveyor Systems

Slat Conveyors

Overhead Travelling Cranes



Sand Conditioning Plant

Overhead Chain Conveyors

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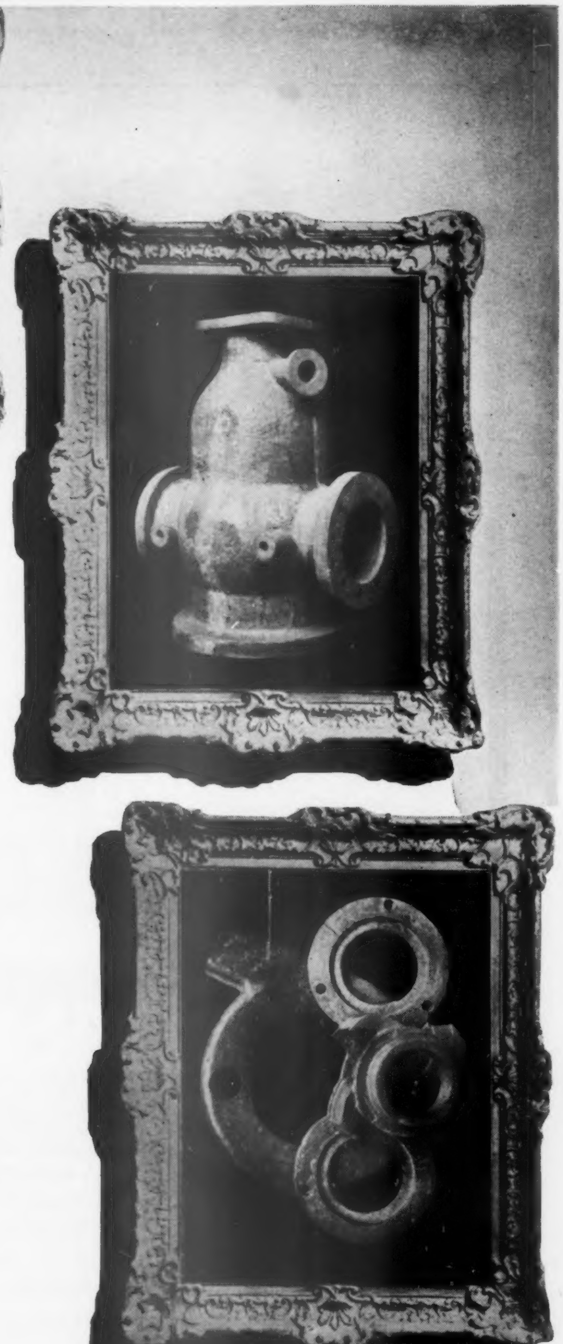

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At every stage of manufacture, from Pattern Shop to Fettling and Finishing, expert craftsmanship ensures that our steel castings are as nearly perfect as the founder's skill can ensure, and conform to B.S.S. or customer's own specifications. The correctness of our methods can be demonstrated, if required, by means of our modern X-ray examination equipment. In carbon, alloy, stainless and heat-resisting steels, for castings of a few lb. up to 13 tons (finished weight), our standard of surface finish, soundness of structure, and dimensional accuracy satisfies **your** requirsments.

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fast metal removal, fine finish, adaptability and best value for money you cannot make a better choice than the . . .
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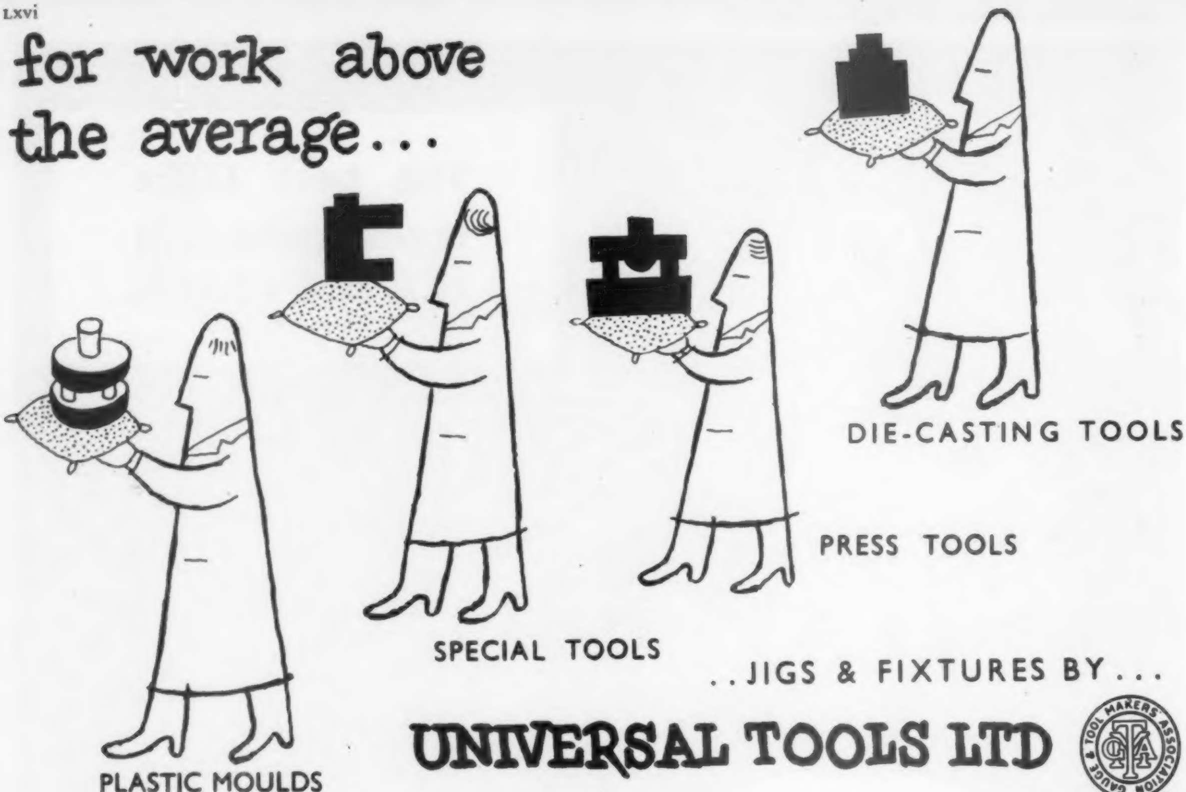

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GAUGE & TOOL MAKERS ASSOCIATION MEMBER

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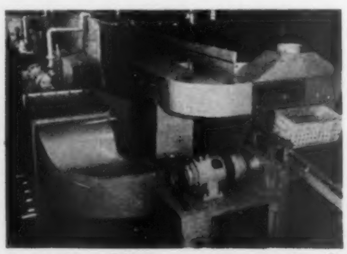
Bratby

INDUSTRIAL CLEANING MACHINES

can be designed to meet your particular cleaning problems

HERE ARE THREE EXAMPLES

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.

Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

Designed and Manufactured by **BRATBY & HINCHLIFFE LTD · SANDFORD STREET · ANCOATS · MANCHESTER 4**

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No skeletons in the cupboard

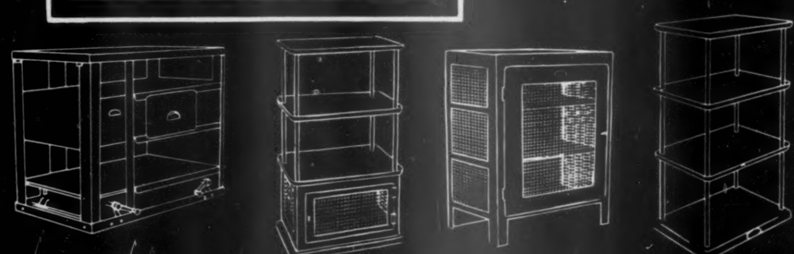
when STEELPACT furniture is keeping production tidy. Work is kept off the floor and tools are where they can be found without fumbling. This essential furniture is adaptable, may be extended into multiple units and is available in various forms and sizes. You will be surprised how little it costs to be efficient with

STEELPACT

WORKSHOP FURNITURE

TYPE 172 TOOL LOCKER

Write for illustrated brochure describing:—Permanent, Semi-Portable and Mobile Work Benches, Tool Stands and Lockers. Inquiries also invited for Foremen's Desks and Testing Benches, Erection Trestles and other special or non-standard workshop furniture.



TYPE 111 WORK BENCH | TYPE 165 TOOL STAND | TYPE 170 TOOL LOCKER | TYPE 161 TOOL STAND

FAWCETT PRESTON

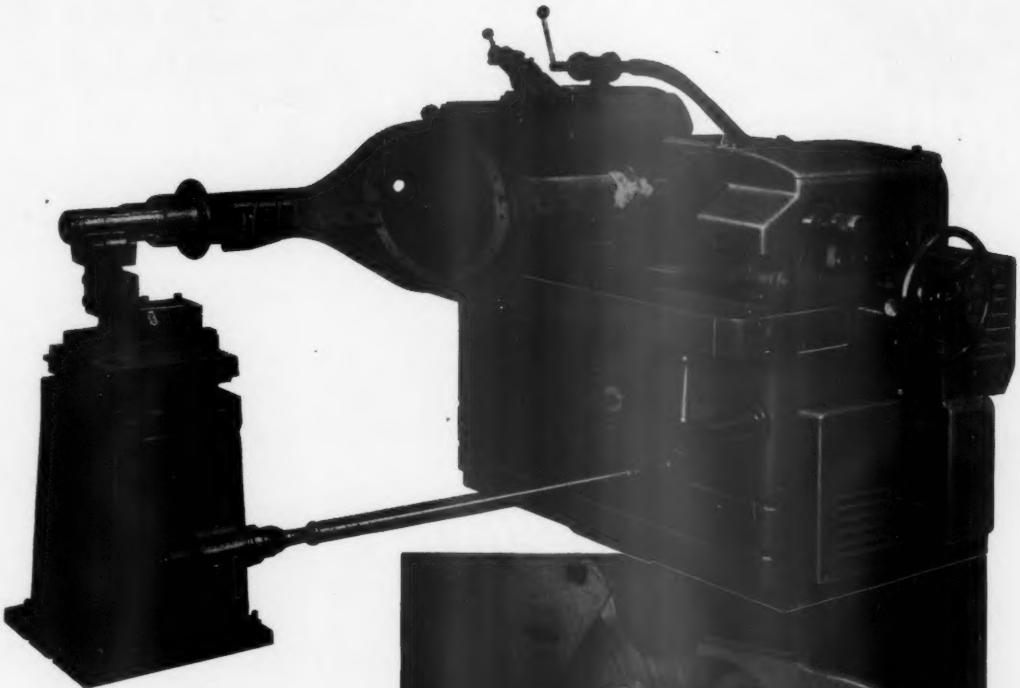
furnishers to production

FAWCETT PRESTON & CO LTD BROMBOROUGH CHESHIRE

ONE OF THE METAL INDUSTRIES GROUP OF COMPANIES

FP2/1/P320

An OUTSIZE job



grinding the ends of a large, fabricated steel, rear axle casing. Time, per end, approx. 2 minutes

on a B.S.A. No. 8 Centreless Grinding Machine

TWO SIZES:

	No. 4	No. 8
Diameter of work ground — — —	$\frac{1}{16}$" to 3"	$\frac{1}{2}$" to $6\frac{1}{2}$"
Capacity for bar grinding — — —	$\frac{1}{16}$" to $\frac{7}{8}$" up to 10ft. long	$\frac{1}{2}$" to 2" up to 14ft. long
Speed of grinding wheel — — —	1,270 rpm.	1,180 rpm.
Number of control wheel speeds —	4	12
Drive — — — — — —	10 hp. 1,455 rpm.	20hp. 1460rpm.
Floor space occupied — — — —	56"x 57"	66"x74"

The machine is equipped with a mechanical in-feed attachment and a specially designed outboard support which compensates for the slight angling of the component axis which occurs as stock is removed. A universal drive, linked to the in-feed mechanism and coupled to a lead-screw inside the support, causes the outer end of the component to traverse forward. The movement is equivalent to half the stock removal, so that the component axis is constantly parallel to the control wheel. Both wheels are form trued

FOR RAPID AND EFFICIENT FINISHING OF TAPER, SHOULDERED, SPECIAL FORM, MULTI DIAMETER AND PLAIN CYLINDRICAL

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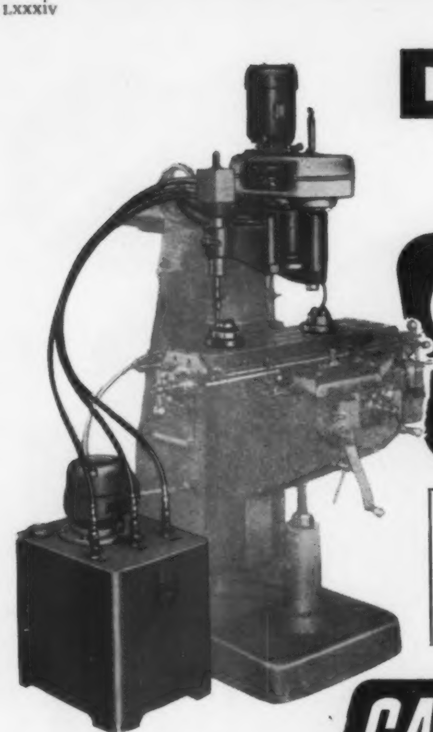
DIE-SINKING . .



Catmur HYDRAULIC DUPLICATOR

on your existing milling machine

DESIGNED to mount on any standard horizontal miller, and some types of vertical miller, the CATMUR HYDRAULIC DUPLICATOR is a highly efficient diesinker and duplicator, reproducing intricate cavities in dies, moulds, etc.

Rapid, fine adjustment for depth of cut, spindle mounted on precision ball bearings in pairs.

May we supply full details?

SPECIFICATION

Number of spindle speeds	6
Range of spindle speeds	400-3,670 r.p.m.
Quill diameter (chrome plated)	3in.
Quill travel	$3\frac{1}{2}$in.
Centre distance spindle/tracer	16in.

CATMUR MACHINE TOOL CORPORATION LIMITED

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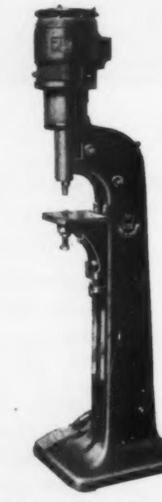
Rairbow

TT RIVET SPINNING MACHINES

for effortless silent riveting !

Whether it's a small aluminium rivet in a fragile component or a large steel stud in a gear box, a TT Rivet Spinner will give it a perfectly finished head and improve the look of your product. The process is quick and efficient—and it is equally suitable in certain applications for spinning over bushes and flanges. Models available for Foot or Air Operation, with capacity up to $\frac{3}{4}$in. dia. in steel. We also manufacture a full range of Rotary Vibrating Riveting Hammers. We offer our expert advice and shall be pleased to demonstrate on your samples.



R.S.5. VMD. $\frac{3}{16}$in. Cap Foot Operated Rivet Spinning Machine

Contact your usual Machine Tool Merchant or:—

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TURNER MACHINE TOOLS LTD.

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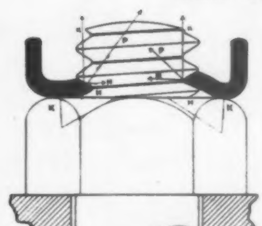
The 'PALNUT' *Safety Lock Washers*

THE HEAVIER THE STRAIN —THE STRONGER THE GRIP



Outstanding Advantages:

(1) Saves costs by ensuring higher efficiency in running and maintenance. Usable on short bolt heads.

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The 'PALNUT' is a lightweight coned disc that engages a single screw thread with a completely circular grip.
Pressure of nut at points KK brings horizontal lines HH nearer to nut, increasing grip.
Available in all threads—Standard Hexagon and small Hexagon Whitworth B.S.F., B.A., Millimetre Threads, Gas Threads, Simplex Threads, etc.

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Vol. 34, No. 1
JANUARY, 1955

JOURNAL SUPPLEMENT

INSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

MEETINGS

Visitors tickets may be obtained from Section Honorary Secretaries

JANUARY 1955

BIRMINGHAM **7.0 p.m. JANUARY 19th**
The James Watt Memorial Institute, Great Charles Street, Birmingham 3.
"Silver and Electro-Plate, Antique and Modern" by I. Shortt, J.P.

BIRMINGHAM GRADUATE **7.0 p.m. JANUARY 11th**
The James Watt Memorial Institute, Great Charles Street, Birmingham 3.
"Productivity and the Machine Tool" by N. Stubbs, M.B.E., B.Sc.

BIRMINGHAM GRADUATE **JANUARY 15th**
Works visit to B.S.A. Tools Ltd.

COVENTRY **7.0 p.m. JANUARY 12th**
Church House, Rugby.
"The Production of Steam Turbines" by D. Liebert and G. Haynes.

COVENTRY GRADUATE **7.15 p.m. JANUARY 5th**
Hare & Squirrel Hotel, Cow Lane, Coventry.
"Production Panel"—Discussions on some aspects of Production Engineering by S. J. Harley, M.I.Mech.E., M.I.Prod.E., E. Beaumont, A.M.I.Prod.E., H. Peter Jost, A.M.I.Mech.E., A.M.I.Prod.E., E. M. Price, M.I.Prod.E., H. V. Field.

CORNWALL **7.15 p.m. JANUARY 20th**
The Cornwall Technical College, Trevenson, Pool, Redruth.
"The Protection of Metal Components against Atmospheric Corrosion" by N. R. Laban, B.Sc., A.R.I.C.

DERBY **7.0 p.m. JANUARY 17th**
College of Art, Green Lane, Derby.
"Glass Production" by C. E. Stubbs.

DONCASTER **7.0 p.m. JANUARY 11th**
The Danum Hotel, Doncaster.
"Optics Applied to Engineering" by Mark H. Taylor, M.I.Prod.E.

DUNDEE **JANUARY 13th**
Joint meeting with the Institute of Welding.

EASTERN COUNTIES **7.30 p.m. JANUARY 14th**
The Diocesan Hall, Tower Street, Ipswich.
"So you want to be a Manager" by Sir Walter Puckey, M.I.Prod.E., F.I.I.A.

GLASGOW **7.30 p.m. JANUARY 20th**
The Institute of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow C.2.
"Shell Moulding" by D. N. Buttrey, M.Sc., A.R.I.C., A.P.I.

HALIFAX GRADUATE **7.30 p.m. JANUARY 19th**
The White Swan Hotel, Halifax.
"Production Panel"—Members' Questions will be put to a panel of experts. Joint Meeting with Halifax Productivity Committee.

LEICESTER **7.0 p.m. JANUARY 13th**
The Balmoral Room, Bell Hotel, Leicester.
"The Varied Application of Drilling Machines in Relation to Production" by W. A. Hannaby, A.M.I.Prod.E.

LINCOLN **7.30 p.m. JANUARY 27th**
The Ruston Club, Unity Square, Lincoln.
"Industrial Productivity Value of Work Study to Industry" by W. H. Hodgetts, M.I.Prod.E.

LIVERPOOL **7.30 p.m. JANUARY 19th**
The Birkenhead Technical College, Borough Road, Birkenhead.
"Prevention of Waste" by R. M. Evans.

LIVERPOOL GRADUATE **9.0 a.m. JANUARY 8th**
Works visit to Messrs. J. Bibby & Sons Ltd., Gt. Howard Street, Liverpool 3.

LONDON **JANUARY 6th**
Works visit to Glacier Metal Co. Ltd., Ealing Road, Alperton.

LONDON **7.0 p.m. JANUARY 20th**
The Royal Empire Society, Northumberland Avenue, London, W.C.2.
"Progress of British Watch and Clock Production" by R. Lenoir, F.B.H.I.

LONDON GRADUATE **7.15 p.m. JANUARY 18th**
The Institution of Production Engineers, 10, Chesterfield Street, W.I.
"The Production Engineer and Economical Use of Technical Information" by P. Spear, B.Eng., Grad.I.Prod.E.

LUTON **7.15 p.m. JANUARY 25th**
The Small Assembly Room, Town Hall, Luton.
"Induction Heating" by Dr. R. H. Barfield, D.Sc., A.M.I.E.E.

LUTON GRADUATE **7.45 p.m. JANUARY 17th**
The Committee Room, Hatfield Technical College, Roe Green, Hatfield.
Joint Meeting with the Works and Production Engineering Department of Hatfield Technical College.

MANCHESTER **7.15 p.m. JANUARY 24th**
Reynolds Hall, Room C.3, College of Technology, Sackville Street, Manchester 1.
"Jet Engines—Basic Principles and Production Problems" by C. E. Wurr.

MANCHESTER GRADUATE **7.15 p.m. JANUARY 11th**
Reynolds Hall, College of Technology, Sackville Street, Manchester.
"Centreless Grinding" by T. Smith.

NORTH EASTERN **7.0 p.m. JANUARY 17th**
Neville Hall, Newcastle-on-Tyne.
"Fundamentals of Machine Tool Design" by C. A. Sparkes, M.I.Mech.E., M.I.Prod.E., Assoc.M.C.T.

NORTH EASTERN GRADUATE **7.0 p.m. JANUARY 14th**
Roadway House, 8, Oxford Street, Newcastle-upon-Tyne.
"Training Within Industry for Supervisors" by H. Williams.

NORWICH **7.30 p.m. JANUARY 5th**
The Assembly House, Theatre Street, Norwich.
"Fuel Efficiency in the Factory" by E. J. Tickner, B.Sc., A.M.I.Mech.E., M.Inst.F.
Joint Meeting with the Institute of Cost and Works Accountants.

NORWICH **7.30 p.m. JANUARY 25th**
The Assembly House, Theatre Street, Norwich.
"The Work of H.M. Inspectors of Factories" by H. H. Tranter.

NORTHERN IRELAND **7.30 p.m. JANUARY 27th**
Lecture Hall, Ulster Farmers Union, 18 Donegall Square East, Belfast.
"Broaching and Broaching Techniques" by A. E. Randall.

NOTTINGHAM **7.0 p.m. JANUARY 5th**
Victoria Station Hotel, Milton Street, Nottingham.
"The Human Aspect in Production Planning and Control" by B. G. L. Jackman, M.I.Prod.E., A.R.Ae.S., M.I.I.A.

OXFORD **7.30 p.m. JANUARY 11th**
The Town Hall Oxford.
"Maintenance Matters" by G. C. Oram, M.I.Mech.E., M.I.Prod.E., A.M.Inst.N.A.

PETERBOROUGH **7.30 p.m. JANUARY 12th**
The Angel Hotel, Bridge Street, Peterborough.
"Valid Incentives" by E. C. Gordon England, F.R.Ae.S., F.I.I.A., F.I.N.I., M.I.Prod.E.
Joint Meeting with the Peterborough and District Group of The Institute of Cost and Works Accountants.

PRESTON **7.15 p.m. JANUARY 12th**
The Crown Hotel, Market Place, Blackburn.
"The Shell Moulding Process" by D. N. Buttrey, M.Sc., A.R.I.C., A.P.I.

READING **7.30 p.m. JANUARY 6th**
The Great Western Hotel, Reading.
"Work Measurement" by Prof. T. U. Matthew, Ph.D., M.Sc., M.I.Prod.E.

ROCHESTER **7.30 p.m. JANUARY 13th**
Sun Hotel, Chatham.
"How the Money Moves in Business" by T. G. Rose, M.I.Mech.E., M.I.Prod.E., F.I.I.A.

SHEFFIELD **6.30 p.m. JANUARY 10th**
The Grand Hotel, Sheffield.
"The Approach to Work Study" by G. R. Lunt.

SHEFFIELD GRADUATE **6.30 p.m. JANUARY 24th**
Messrs. Moore & Wright Ltd., Trafalgar Street, Sheffield 1.
"Jigs and Fixtures" by E. Booth.
(Admission by ticket only, obtainable from the Hon. Secretary.)

SHREWSBURY **7.30 p.m. JANUARY 26th**
Shrewsbury Technical College, Shrewsbury.
"Training for Production Engineering" by E. M. Price, M.I.Prod.E.

SOUTHERN **7.15 p.m. JANUARY 20th**
Polygon Hotel, Southampton.
"Modern Finishing Processes" by K. W. Abineri, B.Sc.(Hons.)

SOUTH ESSEX **7.30 p.m. JANUARY 12th**
The Ilford Bowling Club, Nr. Ilford Station, Ilford.
"Management" by J. E. Currie.

SOUTH WALES and MONMOUTHSHIRE **7.0 p.m. JANUARY 6th**
The South Wales Institute of Engineers, Park Place, Cardiff.
"Standardisation in The Process Industries" by E. W. Greensmith, B.Sc., A.C.G.I., A.M.I.Mech.E.

STOKE-ON-TRENT **7.15 p.m. JANUARY 21st**
The Town Hall, Hanley, Stoke-on-Trent.
"Developments and Applications in the Manufacture of Fibre Glass" by J. B. Mitford.

TEES-SIDE **7.0 p.m. JANUARY 24th**
The Cleveland Scientific Technical Institution, Middlesbrough.
"Work Study Applied to Maintenance Work" by Dr. H. E. North, Ph.D., B.Sc., A.R.I.C., M.Inst.F., A.M.I.Chem.E.

WESTERN **7.15 p.m. JANUARY 19th**
Westinghouse Brake & Signal Company Ltd., Chippenham.
"Mechanical Handling and Work Study" by L. J. Harper.

WESTERN **7.15 p.m. JANUARY 26th**
Beaufort Room, Grand Hotel, Broad Street, Bristol.
"Prelude to Production" by W. U. Snell, A.F.R.Ae.S., A.M.I.Mech.E., M.I.Prod.E.

WESTERN GRADUATE **7.30 p.m. JANUARY 3rd**
The Grand Hotel, Broad Street, Bristol 1.
"Rocket Propulsion" by Prof. A. D. Baxter, M.I.Mech.E., F.R.Ae.S.

WESTERN GRADUATE **7.30 p.m. JANUARY 27th**
The Wheatstone Hall, Glos.
"Ultrasonic Machining" by W. Owen-Roberts.

WEST WALES **7.30 p.m. JANUARY 21st**
The Central Library, Alexandra Road, Swansea.
"Production Control" by R. G. Hitchcock, B.Sc., A.M.I.Prod.E.

WOLVERHAMPTON **7.15 p.m. JANUARY 5th**
The Anchor Hotel, Wednesbury.
"Lock Design and Manufacture" by C. G. Smith.

WOLVERHAMPTON GRADUATE **9 p.m. JANUARY 22nd**
Works visit to Cincinnati Ltd., Birmingham.

WOLVERHAMPTON GRADUATE **7.30 p.m. JANUARY 26th**
The Wolverhampton & Staffordshire Technical College, Wulfruna Street, Wolverhampton.
"Developments in Centreless Grinding Techniques" by Arthur Scrivener, M.I.Prod.E.

WORCESTER **7.30 p.m. JANUARY 26th**
The Cadena Cafe, Worcester.
"Production of Jaguar Cars" by J. Silver.

YORKSHIRE **7.0 p.m. JANUARY 10th**
The Hotel Metropole, Leeds.
"Unusual Products that can be made from Tube" by A. N. Attwood, and L. C. Hackett.

February 1st to 7th, 1955

CORNWALL **7.15 p.m. FEBRUARY 2nd**
The Camborne School of Mines, Camborne.
"British Clock and Watch Production" by A. W. Marshall, F.B.H.I.

HALIFAX **7.0 p.m. FEBRUARY 1st**
The George Hotel, Huddersfield.
"Productivity in Worm Gear Unit Manufacture" by F. J. Everest, M.Sc., A.C.G.I., D.I.C., M.I.Mech.E., A.M.I.E.E., A.I.Mar.E., M.I.Prod.E.

MANCHESTER GRADUATE **7.15 p.m. FEBRUARY 1st**
Reynolds Hall, College of Technology, Sackville Street, Manchester.
"Powder Metallurgy" by Dr. E. M. Trent, Ph.D., M.Met.

NOTTINGHAM **7.0 p.m. FEBRUARY 2nd**
Victoria Station Hotel, Milton Street, Nottingham.
"The Measurement and Significance of Surface Finish" by R. E. Reason.

READING **7.30 p.m. FEBRUARY 3rd**
Transport Equipment Ltd., The Canteen, Worting Road, Basingstoke.
"Practical Application of Production Engineering Research" by Dr. D. F. Galloway, B.Sc.(Hons.), M.I.Mech.E., M.I.Prod.E., A.M.I.E.E.

SOUTH WALES and MONMOUTHSHIRE **7.0 p.m. FEBRUARY 7th**
The South Wales Institute of Engineers, Park Place, Cardiff.
"Business Visit to Moscow" by Lord Verulam, M.A., F.I.I.A. (Illustrated by a film.)

WESTERN GRADUATE **7.30 p.m. FEBRUARY 7th**
The Grand Hotel, Broad Street, Bristol 1.
Production Brains Trust.

WOLVERHAMPTON **7.15 p.m. FEBRUARY 2nd**
Wolverhampton & Staffordshire Technical College, Wulfruna Street, Wolverhampton.
"Economics in Production Engineering" by Dr. F. A. Wells, Ph.D., B.Sc.

Small Tool Salesman with technical background required for London area of well-known Sheffield Company. Must possess unquestionable selling ability. Pension scheme. Age about 30. Applications treated in strict confidence, must state experience, age, terms expected, to Box No. 997, I.Prod.E., 10 Chesterfield Street, London, W.1.

Time Study Engineer. The North British Rubber Co., Ltd., require a Time Study Engineer for their Castle Mills, Edinburgh factory. Should have some experience. Good conditions and pension scheme. Apply in writing, giving full particulars and salary required, to the Office Manager.

Production Executive required for medium-sized, expanding company in Slough, Bucks. The position calls for experience in production management; an engineering background and qualifications, such as Higher National Certificate in Mechanical Engineering, are desirable. The successful applicant will be directly responsible to the Production Manager for a major part of the production organisation. Company pension scheme. Write giving full details to Box 02131, Samson Clark, 57-61 Mortimer Street, London, W.1.

Technical Publicity. A young man with an engineering or metallurgical background is required in the Publicity Organisation of a major aluminium fabricating company to assist in the preparation of technical and sales publications and in other publicity duties. Applicants should be able to produce evidence of their ability and inclination to write. Some artistic ability would be an advantage. Salary will depend very much on age and experience. Please write in the first instance to Box No. 998, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant to Production Manager required by Exquisite Form Brassiere Co. at their Edmonton factory. Age 22/30. Starting salary £400-£700, depending on experience. Sound education, common-sense and willingness to work and learn essential. Some experience production planning and/or statistics and records an advantage. The Company is the largest of its kind in the world and offers excellent prospects for promotion in this country or overseas. Apply General Manager, 92 White Post Lane, Hackney, E.9.

Production Manager wanted by light electrical engineering firm in Bradford, Yorkshire. 700 employees. To be fully responsible for production planning and layout. Time and Motion Study and tooling. Please apply in the first instance, giving qualifications, age and salary expected, to Box No. 999, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Inspector, aged 30/50, for small but expanding engineering firm in Walsall. The position is a senior staff appointment and entails full responsibility for re-organisation of existing inspection procedure. A commencing salary and bonus of £750/£850 per annum will be offered. Applicants should give fullest particulars of experience and technical qualifications. Box No. 1000, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineer required by textile machinery makers in Rochdale, Lancs. Knowledge of production control will be a big asset. A **Ratefixer** is also required for the firm's factory at Darwen, Lancs. Opportunity for further advancement to suitable applicants. Permanent position with pension scheme. Please state fullest particulars of experience and salary required to Box No. 1001, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineer required by member of large group of Companies producing food and allied machinery in Yorkshire. A fully qualified engineer with several years' practical experience required (H.N.C. or Grad.I.Prod.E.) to advise on technical processes and methods in production of variable components of automatic machinery. This is a permanent senior appointment, with a Company of long standing which is expanding rapidly. Contributory pension fund, excellent prospects. Applications, which should state age, education, qualifications and experience, and will be treated in the strictest confidence to Box No. 1002, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Assistant Engineer required at Sub-Area Headquarters at Gloucester. Applicants will be required to assist in the development of the Industrial and Commercial utilisation of electricity supplies. Wide experience of electrical development is essential. Technical qualifications desirable. Salary £975/£1050 per annum (N.J.B. Grade H.5). Superannuable. Apply within fourteen days stating age, experience, present salary and position to Mr. D. Holt, Sub-Area Manager, Midlands Electricity Board, 126 London Road, Gloucester. A. Stephens, Secretary.

Estimating and Planning Engineer. Applications are invited from men with sound knowledge of estimating and process planning in the fields of electronic and light mechanical engineering. A very interesting position will be offered to the right man by a firm of electronic instrument manufacturers in the N.W. London Area. No age-limit. Salary according to experience. Apply with full particulars to Box No. 1003, I.Prod.E., 10 Chesterfield Street, London, W.1.

Top-Level Production Executive of exceptional experience and calibre is required by a progressive group of companies in the light engineering field, accepted as one of the most advanced in its production methods in Britain today. The post demands professional engineering qualifications, practical experience of current production techniques, and administrative ability above the average. The proposed appointment will entail complete responsibility for one of the group's manufacturing units employing up to 2,000 people. Recent experience in the instrument or electronic industry would be an advantage. A salary will be offered commensurate with ability up to £5,000 per annum. Production executives who consider their engineering and administrative qualifications equal to this important appointment are invited to write in strict confidence (and with the assurance of careful consideration at the highest level), to Box No. 1004, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Methods Engineers required—experience and qualifications should include apprenticeship, methods study, design of tools and special purpose machines and experience of all machine shop operations. Experience of process operations, viz. polishing, plating heat treatment, etc., an advantage but not essential. Applications giving full details of age, qualifications, and experience should be addressed to the Personnel Manager, Rolls-Royce Limited, Hillington, Glasgow, S.W.2.

Chief Engineer to control press shop, tool room and maintenance of all plant. Sound knowledge of up-to-date production methods. Practical tool maker, able to undertake design and development of press tools. Must be adaptable and energetic with ability to handle labour and tackle any job. Salary commensurate with responsibile position. Factory S.E. London. Write giving age, qualifications, previous experience and present salary. Box No. 1005, I.Prod.E., 10 Chesterfield Street, London, W.1.

Time Study. An opportunity exists for a young man, aged about 25 with some time study experience, to fill an important factory position with Jantzen Limited, of Great West Road, Brentford, Middlesex, swimwear manufacturers. Previous experience in clothing industry useful but not essential. Work includes timing and costing of new range every year, and assisting in the study and installation of new methods as they are developed. This will give first class training over a number of years for a man having the necessary ability to be a factory manager in the future. Commencing salary £450 - £500. Write to Personnel Officer.

Management Consultants have vacancies for experienced industrial engineers and also for production and work study engineers to train for management consulting work. Applicants must have a university degree or equivalent technical qualifications and preferably a knowledge of production control and operation planning. Applications giving age, and details of qualifications and experience to Managing Director, Industrial Administration (R and A) Limited, Broadmead House, 21 Panton Street, London, S.W.1.

Senior Production Engineer. A well known group of manufacturers has a vacancy for a Senior Production Engineer to take charge of the existing organisation in two or three factories. Applicants should have a wide knowledge of method study, work measurement and incentives

Production Engineer, responsible to the Genera Manager for the functions of tool design and manufacture, production methods, technical planning and work study, required in South Birmingham area. Applicants must be of Higher National Certificate standard and have had good practical experience. Salary up to £1,500 per annum. Apply giving details of age, general and technical education, qualifications and experience to Box No. 984, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Staff required for Gold Mine in the Gold Coast Colony. Commencing salary £65 per month; married employees receive a separation allowance. Continuous contract with twelve months' tour and three months' leave. Passage paid both ways. Free quarters and medical service. A provident fund is in operation. Low income tax. Successful applicants will work under the Chief of Study and must be prepared to make trips underground in the course of their duties. Write Box No. 212, Walter Skinner Limited, 20 Copthall Avenue, London, E.C.2.

Chief of Progress with knowledge of machine loading and progressing jobs throughout required for large light engineering shop. Five-day week. Good salary to right man. Apply: Sterling Engineering Co. Ltd., Rainham Road South, Dagenham, Essex.

Time Study Engineers required for engineering company, covering the manufacture of electrical and mechanical components. Sound knowledge of machine shop practice and modern methods necessary. Good salary to right men. Five-day week. Staff canteen facilities. Apply: Sterling Engineering Co. Ltd., Rainham Road South, Dagenham, Essex.

Chief Planning Engineer. Expanding Company engaged on electronic engineering requires the services of a Chief Planning Engineer in charge of process planning and tool design. University graduate preferred, but ability and experience regarded of greatest importance. Within radius of 30 miles of London. Permanent pensionable position, with a commencing salary of £900-£1200 p.a. Apply to Box No. 985, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production and Planning Engineer. A public company in Scotland producing solid fuel heating stoves and cooking appliances require the services of a production and planning engineer to supervise and introduce up-to-date methods of production of these appliances. Previous experience in the production of solid fuel appliances is not essential but would be an advantage. Permanent position and pension scheme. Please write stating age, experience and qualifications and positions held. Salary will be paid according to experience. Reply to Box No. 986, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Draughtsman required for design of sheet metal working machinery and to take charge of medium-sized drawing office in Central London area. Applicants should have Higher National Certificate in Mechanical Engineering or equivalent. State age, details of training, posts held (in confidence) and salary required, to The Technical Director, F. J. Edwards Ltd., 359 Euston Road, London, N.W.1.

Development Engineer. Old-established light engineering Company in N.W. London area require a young man of H.N.C. standard for interesting work in small section engaged in the design and development of precision mechanisms. Experience in production methods and tooling an advantage. Good starting salary. Write full details of education, experience, etc., in confidence to Works Manager, Box No. 987, I.Prod.E., 10 Chesterfield Street, London, W.1.

Young Sales Engineer. Export Group handling comprehensive range of production engineering equipment require qualified young sales engineer, preferably single, with sound training in workshop practice and all aspects of precision production. Must be prepared to make visits overseas and have right temperament. Some languages useful. Box No. 988, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineer required for metal window factory operating both flow-line production and small batch or jobbing work. A sound engineering background is essential, also a knowledge of modern management techniques including work study and production planning. Promotion to take full responsibility for all production matters should follow rapidly for a candidate with suitable drive and personality. Apply by letter giving full particulars of age, experience, salary required to: Managing Director, "H" Department, John Williams & Sons (Cardiff) Ltd., East Moors Road, Cardiff.

Experienced Motion Study Engineer required for work study department in Midland engineering firm. State age, and full details of previous experience to Box No. 989, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study. Midland engineering firm require several young men, who, having served an apprenticeship, and possessing an Ordinary National Certificate in Mechanical or Production Engineering, would like to train in Work Study. State age, and full details of previous experience to Box No. 990, I.Prod.E., 10 Chesterfield Street, London, W.1.

Young Technical Executive with sound knowledge of up-to-date methods engineering and ratefixing, required by old-established expanding Sheffield company (240 employees) making specialised but interesting line of tools and light machinery. Commencing salary from £700 according to qualifications. Box No. 991, I.Prod.E., 10 Chesterfield Street, London, W.1.

Young Engineer, approximately 30 years, to take control and develop new foundry process. Some design experience necessary and ability to control labour essential. Company situated approximately 20 miles West of London. Applicants should give full details of education, past experience and present salary to Box L.979, Willing's, 362 Grays Inn Road, London, W.C.1.

Assistant General Manager for light engineering works. Sound theoretical knowledge, high educational standards, practical as well as administrative experience and cost consciousness essential. Public company with pension scheme offers excellent prospects for right applicant. Box No. 992, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Production Engineers. Dowty Hydraulic Units Ltd., Ashchurch, nr. Tewkesbury, invite applications for positions as Assistant Production Engineers from Graduates and Associate Members of not more than 35 years of age. The organisation is an expanding one and has an interesting and varied programme of new projects. The vacancies are permanent and progressive and offer considerable scope to the right men. Applications should be addressed to the Personnel Manager and should state previous training, experience and present salary.

Works Manager. Batch Precision Engineering. Age about 40. Strong but tactful personality. First-class qualified engineer with proven management record essential. Exceptional salary and prospects in expanding well-established S. London Engineers. Box No. 993, I.Prod.E., 10 Chesterfield Street, London, W.1.

First-class Machine Tool Engineer required as respresentative to cover West country and South Wales for well-known established company handling high production machine tools. Basic knowledge modern machining methods essential, further specific training given. Salary, commission and expenses. Pension scheme. Own staff informed of this vacancy. Send full details including age and machine tool experience to Box No. 994, I.Prod.E., 10 Chesterfield Street, London, W.1.

Young Graduate Mechanical Engineer. Textile Mill Accessories manufacturer in mid-Lancashire requires a young graduate mechanical engineer as Assistant to the Manager. Some production experience desirable. Age limit 35. Salary commensurate with qualifications. Superannuation scheme. Replies, giving experience and qualifications, should be addressed to Box No. 995, I.Prod.E., 10 Chesterfield Street, London, W.1.

Analytical Chemist required to start up new laboratory controlling medium-size firm's alloyed ferrous material. Capable of routine checks and research into heat treatment technique. Birmingham area. Reply giving age and full details of career to date, when free, and salary required. All replies treated as confidential. Box No. 996, I.Prod.E., 10 Chesterfield Street, London, W.1.

PRODUCTION APPOINTMENTS

BULLETIN No. 52
JANUARY 1955

This bulletin is circulated to all members of the Institution monthly as near as possible to the first of the month. Firms or organisations wishing to insert notices in the bulletin should communicate with the Secretary at 10 Chesterfield Street, London, W.1.

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month. The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. A standard charge of £1 1s. per insertion is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations. Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given:—

(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range. Advertisers are asked to advise the Institution when appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with Institution standards. *Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box Nos.*

All advertisements appearing in this Bulletin are subject to the Notification of Vacancies Order of 1952.

Designer—Draughtsman with experience in the design of special purpose machines for mass production by automation including transfer mechanisms, hydraulically operated units as well as press tools. (Presses up to 350 ton capacity.) National Certificate (Ordinary or Higher) would be an advantage. Substantial salary for really first-rate man—age 30-40. Excellent prospects. Staff Pension Scheme. Apply Personnel Department, Box No. 977, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Engineer's Assistant required for a rapidly expanding medium-sized firm in the Luton area. Applicants must have a wide experience of manufacturing processes with particular emphasis on the production of sheet metal pressings and light electro-mechanical assemblies. Preference will be given to engineers with an inventive flair capable of carrying out important development work. A substantial salary is offered and after a suitable probationary period the selected applicant will participate in the Company's non-contributory pension scheme. Apply, Chief Engineer, Box No. 978, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineer. A North London factory require the services of a Production Engineer with good modern experience to take charge of small department producing non-ferrous components. Knowledge of pressing, forming, piercing, blanking essential. Some administrative experience an advantage. Apply, giving full particulars of training, qualifications and experience, to Box No. 979, I.Prod.E., 10 Chesterfield Street, London, W.1.

First-class Liaison Man. K. & L. Steelfounders & Engineers Ltd., Letchworth, in designing and producing large diesel-mechanical mobile cranes, have a vacancy for a first-class man to act as whole-time liaison between drawing office and engineering methods. More than half his time would be spent in the D.O., on call for advice as to machine capacity and choice of methods, so as to ease and speed methods department work on receiving drawings. Applicants should be over 35, preferably from heavy vehicle or similar manufacture, and must be fresh from up-to-date batch production in a thoroughly modern works. H.N.C. is viewed favourably, but not necessary. Past experience of tooling, methods layout and sequence is taken for granted. Tact and pleasant personality are essential. Both departments would make the right man very welcome; present staff know of the vacancy. An excellent salary is envisaged but this would be commensurate with age and calibre. Generous pension scheme in existence and assistance could be given with housing.

Planning Engineer. A large firm of communication engineers in the London area have a vacancy for a Planning Engineer on capacitors. Candidates with or without capacitor experience will be considered. Apply stating age, experience and salary expected to Box No. 980, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer required. Applicants should have had training in method study and time study and at least three years experience in works applications. Apprenticeship or practical machine shop experience essential. Candidates should hold a Higher National Certificate. Five-day week with welfare facilities and contributory pension scheme. Write stating details of experience and present salary to Men's Employment Officer, Guest, Keen & Nettlefolds (Midlands) Ltd., Heath Street, Birmingham 18.

Motion Study Engineer with experience of process charts, micromotion photography and chronocyclegraph study required. State age, full details of experience and salary expected. Apply in writing to Men's Employment Officer, Guest, Keen & Nettlefolds (Midlands) Ltd., Heath Street, Birmingham 18.

Senior Sales Engineer required as assistant to Sales Manager. Must be experienced in technical sales correspondence, estimating, and tendering for engine driven equipment. Apply in writing to Russell Newbery & Co. Ltd., Essex Works, Dagenham, Essex.

Production Engineer. We have an urgent need for a Production Engineer at our Kilmarnock Factory. The ideal applicant will be a young qualified engineer (B.Sc. Eng. or H.N.C.) who has had practical as well as theoretical training—preferably as an engineering apprentice. He will have an alert and inquiring mind which will enable him to investigate methods currently used in the manufacture of plain bearings, initiate improvements and assist with the development and introduction of new processes. Commencing salary £650-£800 according to qualifications and experience. Good prospects and working conditions. Applications to Personnel Manager, Glacier Metal Co. Ltd., Kilmarnock.

Engineers. Progressive posts available for engineers with general or specialised experience in all manufacturing activities encountered in the engineering industry. Commencing salaries in accordance with age, qualifications and experience. Increments on merit. Those with suitable ability will be advanced to responsible positions in an expanding organisation in the Midland area. Duties include visits to engineering firms throughout the country. Excellent superannuation scheme. Apply giving full details including age, experience, qualifications, salary, etc., to Box No. 981, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Engineer required for factory (Wolverhampton area), producing medium-size welded fabrications on batch production basis. Applicants should be conversant with modern welding techniques and machine shop practice. Responsibility would include control of the following sections: tool drawing, planning and estimating, time and motion study, material and production control. This is a difficult job, but for the man possessing initiative and drive who is prepared to work hard in a rapidly expanding department the scope is wide and progressive. All applications will be treated in the strictest confidence and should contain fullest details to Personnel Manager, Box No. 982, I.Prod.E., 10 Chesterfield Street, London, W.1.

Mechanical Engineer, Production Engineer and Works Manager required by an important organisation with interests throughout the British Isles and Commonwealth. Remuneration is on the highest scale with excellent prospects. Age not over 45. Full details of qualifications, posts held and salaries to Box No. 983, I.Prod.E., 10 Chesterfield Street, London, W.1.

and must be fully competent to implement defined policy; this will require organising ability and the exercise of tact, initiative and sound judgement. The appointment which is pensionable, is likely to be progressive and rewarding to the right man. Preferred age 35 - 45. Commencing salary according to qualifications and experience but £1,200-£1,400 is indicative. Applicants, which will be treated in strict confidence, should give full details of education, training and experience; some indication of salary levels already achieved would be useful. Write 18X0, Wm. Porteous & Co., Glasgow.

Senior Production Engineer is required by progressive manufacturers to take charge of methods development, work measurement and payment by results in a small group of factories. A University degree and organising ability are essentials: preference will be given to men with wide experience of production engineering who are accustomed to employing initiative and judgement in the responsible implementation of policy. Age 35 - 45 preferred. Applications, giving full details of education, training and appointments held should be sent in confidence. Write 18X1, Wm. Porteous & Co., Glasgow.

Methods Engineer required by Sentinel (Shrewsbury) Limited, Shrewsbury, to be responsible for the establishment and development of a methods engineering Department. First class experience of work study and work measurement is necessary and the ability to obtain results. The appointment is a senior one and a substantial salary will be paid. Applicants are requested to write stating age and giving full details of education, training, experience and positions held with dates to Managing Director, Sentinel (Shrewsbury) Limited, Shrewsbury.

EDUCATIONAL APPOINTMENTS

Denbighshire Technical College, Wrexham.
Assistant (Grade B) in Mechanical Engineering required at the above College. Candidates should possess a degree or equivalent qualification with suitable industrial and/or teaching experience. Candidates required to take Workshop Technology at Ordinary and Advanced Level with ability to teach extra Welding Science and Technology, Motor Vehicle Technology or Workshop Practice. Salary in accordance with Burnham (Technical) Scale. Forms of application from Edward Rees, Esq., M.A., LL.B., Director of Education, Education Offices, Ruthin.

Brooklands County Technical College, Heath Road, Weybridge.
Assistant in Production Engineering (Grade A or B). Applications are invited for the post of Assistant in Production Engineering (Grade A or B). The work will be concerned with Ordinary National Certificate Courses in Production Engineering and the City and Guilds of London Institute Trades Courses requirements in allied subjects. It is intended eventually to develop the work to Higher National certificate standard. Applicants should possess sound technological qualifications and good industrial experience. Teaching experience is desirable. Preference will be given to those with a knowledge of machine tools, jigs and fixtures, metrology, heat treatment and welding practice. Salary scale for men: Assistant (B): £525 x £25/20—£820 p.a. Assistant (A): £450 x £18—£725 p.a. Assistants may receive additions to scale for approved qualifications and study. Commencing salary dependent upon previous teaching and other approved experience. Duties for this post will include some evening teaching. Application forms obtainable on receipt of stamped addressed envelope from the Principal to whom they should be returned within 14 days of the appearance of this advertisement.

The College of Aeronautics, Cranfield, Bletchley, Bucks. Lecturer required in the Department of Aircraft Economics and Production, to deal as far as possible with the following subjects: machine tools, aircraft production processes, jig and tool design, metrology. Candidates should be graduates in engineering or possess equivalent qualifications and preference will be given to those with aircraft tooling experience. Salary within range £600 to £1,000 p.a. with superannuation under F.S.S.U., and family allowance. Applications giving full details of qualifications, etc., and quoting the names of three referees should be addressed to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. Further particulars available.

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